THE WAYS OF THE MIND

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THE STUDY AND USE OF PSYCHOLOGY

BY

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FOREWORD

A knowledge of psychology is no longer a luxury; it is a necessity. The use of psychological principles has permeated all problems of life. Educational practice is based upon psychological facts. Modern business, on the human side, must be founded upon a sound psychology. In criminal and juvenile courts, it is left to the psychologist to determine the mental responsibility of the defendent. From the mart to the home, from the battle-field to the playhouse, psychology is, where people are concerned, the court of last resort. And the appeal must, under present conditions, be made to the specialist.

So much psychological fraud has been practised that it is difficult for the untrained to separate the good from the bad. It is, consequently, an opportune time to offer on the subject a book which is both accurate and simple. I have striven for accuracy in this book by giving the fundamentals concerning which there is common agreement; for simplicity by omitting debated points and by using simple language and many illustrations; for clearness by presenting the points in a logical order, making each develop naturally from what preceded.

That the knowledge derived from it may be applied to the problems of every-day life makes this book of practical

use. In pursuance of this aim, certain topics—interest, desire, originality, intuition, concentration, motives, and incentives—have been expanded into separate chapters.

I am indebted to Professor W. B. Pillsbury for reading the manuscript and making many helpful suggestions.

H. F. A.

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CHAPTER I

NATURE AND FUNCTIONS OF PSYCHOLOGY

TRADITIONALLY, a book on a scientific subject opens with a definition, or marking off, of the field to be explored. In the present case, however, conventional procedure offers peculiar difficulties.

The newspapers, because of popular demand, print the unusual, the thrilling; facts which on account of their wide departure from the average may be called abnormal. By so doing they obey one of the fundamental laws of interest, but create an impression representative of less than five per cent of the existing conditions. The department of psychology at a large mid-Western university, for instance, offers approximately one hundred semester hours of courses, two hours of which, or two per cent, are given over to abnormal psychology. Yet the notion created by the newspapers is of a psychological content composed chiefly of mediums and spirit messages, telepathy, hypnotism, mind-reading, and dream analysis.

Advertisements in magazines have suggested the existence of a miracle-working psychic power which, lying dormant in all, needs only to be quickened by the advertised course to make success obligatory. That it may develop into a Frankenstein monster which ultimately enslaves its possessor is not mentioned. The resulting attitude toward

psychology is not unlike that held toward the alchemy of old — dangerous to tamper with, for it might lead to undue intimacy with the powers of evil. This suspicion makes psychology at once attractive and fearful.

The much-discussed applications of psychology to business have led to the conjecture that the subject deals mainly with motion-pictures of the movements involved in certain "jobs," habit formation, standardized conditions, fatigue study, tests, and selection of individuals for certain tasks.

All of these impressions contain a germ of truth, but none of them the whole truth. The situation suggests the story of the blind men who went to examine the elephant. One thought him a house, the second a rope, the third a tree, the fourth a fan, the fifth a snake, and the sixth a wall. Each idea, while true in part, was a very incomplete picture.

A still further obstacle to definition lies in the "vagueness" of the material. The field of psychology includes the mental realm, a territory practically unexplored by the average possessor of mind. His information about it is consequently as vague as that of the old map-makers concerning America.

Possibly an indirect method of approaching the problem will be more profitable. The human being is a practical object in a world of other practical objects. But he is practical only as he knows and does. If he knows but does not do, he is theoretical; if he does not know, he cannot do, and so is impractical. Both knowing and doing are necessary in the common-sense world. One who has lost his sight is deprived of a source of information and conse-

quently is less practical than one in full possession of his senses. One who has lost his legs is thereby limited in his ability to do, and so is less practical than a whole man.

A motor-car, likewise, is said to be a practical means of transportation; but it knows nothing and consequently can do nothing. Hence it becomes useful only when controlled by knowledge. No one has seriously asserted the existence of an automobile psychology, yet, by general consent, a human psychology prevails. Comparison of the machine with the human will bring out certain differences, which may shed some light upon the nature of psychology.

To be of any practical use, both the human being and the machine must be capable of movement, and the movement must be controllable.

Production of movement requires some sort of fuel which, when consumed, furnishes power. In the case of the motor-car, the energy-producing material is contained in the gasoline tank. In the case of the human being it is the food and drink which, when digested and assimilated, lies stored in the tissues — bony, muscular, glandular, and nervous. Here it lodges in the form of potential energy, awaiting the spark which will touch it off and render it kinetic.

The spark which ignites the fuel is found in the case of the motor-car at the spark-plug, where it causes the explosion of the gasoline. The necessary electric current is obtained from the battery or magneto. The human battery is the outside world, the environment. From it energy arrives by way of the sense-organs — eyes, ears, nose, tongue, skin — and flows through the nervous system until it reaches muscular tissue. Here it causes combustion of the stored-up energy, with the result that the muscle fibres

shorten and thicken, thus exerting a pull between their two ends.

In the vast majority of instances the voluntary muscles are attached to the bones of the skeleton. The bones are joined one to another in such a way that they form series of levers. When a muscle contracts, that is shortens and thickens, it exerts a pull causing the bones to which it is attached to change their relative positions. To reverse the movement requires force exerted by an opposed muscle pulling in the opposite direction. The bony and muscular systems of the human being resemble in their form of action a crane or derrick of very great complexity.

The involuntary muscles are not attached to bones but form a part of the walls of such structures as the alimentary canal. The nerve-current that causes them to contract is usually the result of some condition in the structure itself. When food is taken into the mouth and swallowed, concentric rings of muscle, by contracting just above the food, force it into the stomach.

But the electric current coming from the battery of the motor-car has a second use. In addition to furnishing the spark for exploding the gasoline, it may be used to give light. Outlining the pathway, revealing the turns, bumps, obstacles, and signs, illumination is an essential adjunct for the successful operation of the machine. In the case of the human being, also, the energy derived from the environmental "battery" may, in addition to causing contractions of the muscles, cause nervous action in the brain substance, the results of which are indicated by the familiar term consciousness. In a *figurative* way, consciousness is not unlike the lighting system of the machine, for it out-

lines and selects the pathway in which one shall move, revealing the turns, signs, bumps, and obstacles. To describe this phenomenon the term mental activity or movement may be used.

But movement alone leaves much to be desired, for control also is necessary to render it serviceable. Unless the movement can be started, stopped, accelerated, or retarded, unless its direction can be adjusted to the practical demands of the situation, it is of little practical value.

Control of direction of movement may be the result of either external or internal causes. In the case of the machine it is always external, coming from the application of an outside force — an intelligent hand on the steering-wheel, rails and flanges, force of gravity, friction, resistance, and the like. In the case of the human being, also, control may result from external causes. Physical restraints, as impassable barriers or prison walls, physical compulsions, as the force of gravity or inertia, very effectively control human action. In the case of the human being, internal or mental forces, such as desires, ideals, fears, sense of duty, are also operative in controlling the direction of movement.

Comparison of the human being with the machine has disclosed certain similarities and differences which may be summarized as follows:

FUNCTION	MACHINE	HUMAN BEING
Driving power	External	External or internal
Starting	External	External or internal
Stopping	External	External or internal
Speed control	External	External or internal
Steering	External	External or internal

The essential difference between the human being and the machine is to be found in the wholly external control of the latter. For effective, useful action, an intelligent driver must be put in control of the machine. The human being similarly may be controlled by external forces, but he may also be self-driven, controlled by the mind which is part of him.

Consequently, psychology has as its subject-matter three different though related topics. One is the study of consciousness, or mind, or intelligence. The second is the mechanism of movement, its causes and its results. The third is the relation of consciousness to movement, and of movement to consciousness.

Further evidence concerning the nature of psychology may be obtained by comparing its subject-matter with that of other allied sciences. Ethics as well as psychology deals with human conduct, the reasons which prompt action and the anticipated results. But where psychology deals with the causes and results of particular individual acts, ethics divides deeds into general groups, such as criminal or altruistic, grouping them as they are good or bad, and as a result evolves rules of moral conduct. Psychology disregards the classification of conduct into good and bad, and contents itself with the discussion of the origins, developments, and uses of motives and their relation to the resulting conduct.

Physiology treats of the movements and behavior of the particular mechanisms of the human body — digestion, respiration, nervous action. The emphasis is rather upon the machine and how it works than upon the conscious condition preceding and succeeding its use.

Economics also postulates laws of human conduct, but tends very generally to disregard the human or psychological element, jumping from the cause of the action to its effect. Economics deals essentially with mass activity and averages, psychology emphasizes to a greater extent the purely personal side, including the links which have been omitted in the economic reasoning.

In general, then, it may be said that psychology is the study of the actions, both mental and physical, of living animals. It classifies, describes, explains, and postulates laws, and because it does all of these it is a science.

The psychologist gains his knowledge by observing the things he is studying. However, since a single observation is of little value unless it is related to others of like nature, he experiments. A psychological experiment consists in observing the behavior of others under standardized conditions and recording the responses in some form of graphic record. A large part of the equipment of any psychological laboratory is composed of instruments devised to aid in obtaining graphic, visible, enduring records. Skill in experimentation consists, not only in the selection of problems to be studied, but also in ability to control the conditions so as to isolate the particular point in question. Because the conditions are standardized, the experimenter can repeat his observations as many times as may be necessary to prove his point. Because graphic records are kept, those obtained at one time may be compared with those secured at other times. An experiment is, consequently, a series of controlled observations.

But observations and experiments upon behavior constitute only one of the complex tasks of psychology. The

study of consciousness is equally important. But here a difficulty arises, for one person cannot perceive the conscious processes of another. He can observe his own consciousness, a proceeding known as *introspection*, and report upon what he finds. By repetition under controlled conditions, he can experiment introspectively.

Introspection is an important method if wisely used, but it has its dangers as well as its advantages. The method is useful because it is the only possible way to get direct information about the consciousness of oneself or of another. It is valuable because it enables us to ascertain what is in mind, what items are important. It permits us to correlate bodily expressions with changes in the content of consciousness. It is the main source of our information about the emotional life. Without it psychology would be as picturesque as a blue print.

But the use of introspection is attended by several risks. Because it is impossible to observe directly the consciousness of another, the psychologist is forced to rely upon the report of the introspecting individual, with the attendant possibility of two very different sorts of fallacy. Interpretation of the introspection consists of explaining the unknown in terms of the known and familiar. Consequently, the introspections of another must be understood by a comparison with one's own mental processes. This may lead to the uncritical assumption that experiences which have a common name are, for different persons, either identical or very similar. The same object may be called red by many persons, yet the "red" consciousness of one may be very different from the "red" consciousness of another. On the contrary, they may be exactly alike.

There is no way of telling, for one person can never see the "red" of another. If this is the situation with simple sense-impressions, how much more fallacious is the identification of two angers, two fears, or two abstract ideas.

In the second place, many factors co-operate to make introspection faulty on the part of the observer. He cannot introspect and report his conscious processes at the same time. What is mentioned must be remembered, and memory plays many strange tricks. Suggestion by the experimenter will lead the one introspecting, in all innocence, to report many bits of data which had no existence in his consciousness until the seeds were sown by another.

However, introspection is a useful and valuable supplement to experiment. By repeating introspections under controlled conditions many of the dangers are mitigated, and much of real value, unobtainable in any other way, is discovered.

Psychology, then, in addition to its own distinctive technic of introspection, uses the methods of the other sciences, observation and experiment. Psychological procedure is very similar to that of physics, chemistry, geology, botany, and the other sciences. It is different because it studies a different body of knowledge, the actions of living animals.

The physical sciences, from one point of view, find their phenomena very simple to observe, for there is little variability in the repeated measurements of the same substance. If a piece of carbon is weighed ten times, the chances are its weight will not twice be exactly the same, but if the difference is much over one per cent the chemist will

blame his scales. For him ten grams of carbon equal ten grams of carbon. For the psychologist, on the other hand, one human being does not equal one human being. Even the same person is different at different times; in fact, he is never twice alike. For example, one man who was experimenting on memory found that when he relearned a series of nonsense syllables after a lapse of six days, there was a saving of 2.5 per cent of time because of the original learning. At another time the saving amounted to 40.3 per cent. The man was the same, in name at least, the interval the same, the degree of original learning the same, the materials learned were very similar, yet the results showed great divergence.

When one human being is compared with another, the differences are even more striking and interesting. The study of individual differences, called Variational Psychology, is one of the newest psychological undertakings. The magnitude and range of the differences between individuals is sufficient to constitute a perplexing problem in itself and to make the technic of psychological investigation more cumbersome and tedious than is the case in the physical sciences, for in psychology many more measurements are demanded for the development of a norm or average. Consequently, the laws and doctrines to be outlined in this work are to be considered as expressions of average tendencies and not as principles that will include all human beings.

In concluding the chapter, certain other branches of psychology should be mentioned. When it studies the behavior of the lower animals, it is called Animal or Comparative Psychology. When the behavior of human beings

is under consideration, it is known as Human Psychology. The study of individuals very much above or below the average, of those who show wide departures from the norm or standard, is called Abnormal Psychology. When the behavior of a special group is observed, almost any modifying adjective may be used as long as it is descriptive of the group. The characteristic responses of soldiers to war-time conditions may as well be called the Psychology of War as anything else. Similarly, the study of gamblers under their professional conditions becomes the Psychology of Gambling. Illustrations might be multiplied endlessly, but possibly enough have been given to clarify the point.

To summarize: Psychology is a science which has as its subject-matter the study of the consciousness and behavior of living organisms. In common with the other sciences, it obtains its data by observational and experimental methods. It has, in addition, a method peculiar to itself in introspection. For consciousness may be aware, not only of external events and objects, but of itself as well.

PROBLEMS

1. A text-book in psychology usually contains discussions of the following topics. Check the topics which should be included when each of the following definitions is given:
   (*a*) Psychology is the science of human behavior.
   (*b*) Psychology is the science of mind.
   (*c*) Psychology is the science of consciousness.

	A	B	C
Stimulation............			
Sensation..............			
Perception.............			
Attention..............			
Memory...............			
Imagination............			
Reasoning.............			
Affection..............			
Emotion...............			
Reflex action...........			
Instinctive action.......			
Habit..................			
Purposive action........			
The self...............			

2. What different factors would be considered by the economist and the psychologist in the law of supply and demand?
3. From what different standpoints would the physicist and the psychologist consider the phenomena of color?
4. From what different standpoints would the physiologist and psychologist discuss the phenomena of digestion?
5. Compare observation and introspection, bringing out as many likenesses and differences as you can.

CHAPTER II

GENERAL SURVEY OF CONSCIOUSNESS

CONSCIOUSNESS is one of the words which can be defined only in terms of itself. It must be experienced to be known, and experience says that consciousness is essentially awareness. The two terms may be used interchangeably, for whenever one is aware of anything he is conscious of it, and conversely, when he is conscious of anything he is aware of it. Only when the word is compared with others does its meaning tend to become more specific. It is then apparent that consciousness exists only in the present; past consciousness is dead, future consciousness unborn. Consciousness itself continues as an awareness of one event after another, and the succession of occurrences is ordinarily as smooth and continuous as the flow of power to the running mechanism of the motor-car. Such a succession of events creates the impression of a forward movement in time, a flowing, which has led to the descriptive phrase, stream of consciousness.

Consciousness at any moment is complex, made up of many parts. As I write these lines I am aware, not only of the paper, the pencil, the thoughts I am trying to express, but also of the noises of the passing vehicles, the clatter of dishes in the kitchen, the voices of playing children. Each of these single experiences is known as a *mental process*. Consciousness at any time is composed of a *pattern* of mental processes. This pattern endures briefly, then, by rearrangements, additions, subtractions, shifts of

emphasis, changes and becomes different. One might substitute the word picture for pattern were it not that the former suggests always something seen. In consciousness, the pattern is made up of many forms of experience — sight, hearing, smell, taste, muscular and organic, resulting in a peculiar medley of qualities.

As in a picture, however, certain details are subordinated, others emphasized, so that one element in the pattern stands out more prominently than others, and becomes the centre of interest. This condition of outstandingness or prominence in consciousness is known as *attention*. Attention, then, is the name given to our awareness of the most potent, we might almost say the most intensive, element in the pattern. We are, to be sure, aware of the other components, but to a lesser degree.

Once again we find that the mental process is complex, made up in turn of a number of lesser elements. For example, as my gaze wanders over the house across the street, I see that it is made of brick and stucco. The bricks are red, not rich and deep, but the shade obtained from mixing red with black and white. Even as simple a thing as the color of a brick is complex, analyzable into at least three more elementary qualities, red, black, and white. The problem is similar to the chemical analysis of matter. Matter is composed of molecules, molecules of atoms. Consciousness is made up of mental processes, mental processes of *sensations*. The sensation is analogous to the atom, the mental process to the molecule, consciousness to matter.

Yet we must not be misled by the analogy. The distinctions between mind and matter, between conscious-

ness and substance, between the physical and the mental are of far-reaching importance for an understanding of the subject. Far too often people identify mind with brain, when a moment's reflection would show the absurdity of so doing.

Physical objects are measured and defined in units of space and time. Size is extent or distance, position is a location in space, weight is essentially distance, speed is distance in a certain time, color is rapidity of ether vibrations, tone rate of air vibrations. Throughout, time units and space units are the characteristics of physical objects.

Consciousness, on the contrary, exists in time, but does not occupy space. Mental processes have neither length, breadth, nor thickness, weight nor specific gravity, momentum nor inertia. Yet, paradoxically, most text-books of psychology state that some sensations at least possess the attribute of extensity, which obviously is a spatial characteristic. The difficulty, however, is not a real one, for closer scrutiny of these writings assures us that they mean, not a large idea, but an idea of something large. When we ask what is the origin of the idea of magnitude, we find that it reduces to duration of some mental process. Ideas do not occupy space, though they may come to mean space.

Knowledge of physical objects may be shared by many at the same time; but a mental process can be known only by its possessor; it cannot be seen, heard, tasted, smelled, handled, or felt by others.

From the purely common-sense point of view, a mental process is the result of nervous activity. Its existence is, in a way, similar to the appearance of light when the electric

current runs through the wires of the incandescent bulb; its disappearance not unlike the fading of the illumination when the current is turned off. The physical structures, the nervous system and incandescent bulb, are enduring; the light and the mental process intermittent, occasional, coming into existence only as the result of physical forces operating in physical mediums.

So far, we have been speaking as if consciousness were composed only of elements of knowledge. But this is not true, for in addition to the knowing or cognitive elements, there can also be discerned feeling and emotional units, known as *affections*. Having the two opposed qualities of pleasantness and unpleasantness, they supplement knowledge by informing us whether we find the sensation agreeable or disagreeable, pleasant or unpleasant.

Mind is the term used in referring to the different experiences which have been organized into systems, which have acquired meanings, which may lead to anticipations and thus become useful in the control of thought and action. Mind is constantly growing with the acquisition of new experiences. It may refer to past, present, or future. Consciousness, on the other hand, is limited to the awareness of the passing moment, and is without past or future implications. To extend a figure previously used, if consciousness corresponds to the illumination coming from the incandescent bulb, mind is analogous to the electric sign in which the individual lights are organized into meaningful patterns, which carry a message to the observer.

The immediate cause of consciousness is, according to common sense, the stimulation of one or more sense-organs. Conversely, without stimulation of the sense-organs,

consciousness cannot exist. Spontaneous mental combustion never occurs.

A good illustration of this fact is found in the case of Strümpell's anæsthetic boy. The young man was completely insensitive except for one eye and one ear, which functioned in almost the normal manner. When the sensitive eye was covered with a light-tight bandage, and the hearing ear plugged with cotton, the boy "went to sleep." In this condition he stayed until the obstructions to sensation were removed. Then he "woke up." In other words, when external energy was denied access to the brain, by way of the sense-organs, consciousness faded away; when external stimulations were readmitted, consciousness reappeared. Consciousness, then, is not self-starting and self-perpetuating, but depends for its existence upon a supply of energy received from the external world.

During the process of human evolution from the one-cell organism, different kinds of cells have acquired distinctive and separate characters, some specializing in sight, some in digestion, others in circulation. In other words, some have gradually changed into bony cells, others into muscular, and still others into nervous cells. In the development of the sense-organs, certain nerve-cells have become further specialized so that they are set into activity by a particular form of physical energy. One type, for example, responds to mechanical pressure, another is set into activity by temperatures below twenty-eight degrees centigrade, another is stimulated by air vibrations. Each specialized ending, whenever stimulated and no matter how stimulated, responds with its own characteristic and peculiar quality.

Our sense-organs are arrangements for holding together certain kinds of specialized sensory nerves, and sometimes accessories are added to concentrate the physical energy more completely upon the sensitive part. The activity of the sense-organ in turn is propagated through the cells of the nervous system, until it terminates in the modified nerve-endings in the muscles. Here it causes contraction of the muscle fibres, thereby returning to the physical world the energy derived from it by way of the sense-organs.

In its course through the nervous system, the nerve-current, which is in many respects similar to the electric current, flows through a number of different structures, all nervous in character. Only in the cerebrum or big brain is any conscious effect produced.

Each sense-organ is connected with a particular part of the cerebrum. Sense-organ activity when transferred to its cerebral terminus results in the awareness of some characteristic of the stimulating object called a *quality*. In fact, sensations, as such experiences are called, are the result in consciousness of the activity of one type of modified sensory ending. Sensations report only the qualities of objects, and these qualities are the raw materials of the knowing side of consciousness.

Some eight families of sensations have been isolated to the present time. They resemble in a way the families of chemical elements, for each family is composed of several members which resemble each other closely, but are very different from the members of other families. In the form below are given the families with the qualities included in each:

SENSE-ORGAN	SENSATION	QUALITIES	STIMULUS
Eye	Vision	CHROMATIC 1. Red 2. Green 3. Yellow 4. Blue ACHROMATIC 1. Black 2. White	Ether vibrations
Ears	Hearing	Noises Tones	Air vibrations
Skin	Cutaneous	Cold Warmth Pressure Pain	Temperature Pressure
Nose	Smell	1. Ethereal—fruit odors 2. Aromatic—camphor 3. Fragrant—most flowers 4. Ambrosiac—musk 5. Alliaceous—garlic 6. Empyreumatic—coffee 7. Hircine—cheese 8. Virulent—opium 9. Nauseous—decaying animal matter	Chemical
Tongue	Taste	Sweet Salt Sour Bitter	Chemical
Muscles and tendons	Kinæsthetic	Muscular and tendonous	Pressure
Internal structures	Organic	Hunger Thirst Nausea Sex	Specific condition of the structure
Vestibular part of internal ear	Labyrinthine	Dizziness	Pressure and inertia of liquid

These thirty or more sensation qualities are the only source of information concerning the external world and our own bodies as well. They may be mixed and combined in various ways to give other complex experiences, they may be recalled in the form of images or memories, they may be accompanied by affective phenomena, but these are different problems which will be met when the time comes. At present we are interested in the elements.

To the law that external stimulation is necessary to produce consciousness, should be added a corollary — that the stimulation must be sufficiently intense to furnish energy to arouse the cells of the cerebrum into activity. This layer of cells, known as the *cortex*, is the only part of the nervous system directly correlated with consciousness. It is perfectly possible to imagine a stimulus, a light, for example, too weak to be seen. Either the physical energy is too weak to cause the necessary nervous reactions in the eye, or the nervous energy aroused in the eye is too feeble to force its way to the cortex, or the amount coming to the cortex is insufficient to arouse the nerve-cells to activity. A certain minimum intensity of stimulation is necessary for the arousal of consciousness.

A second corollary is that the stimulus must be of sufficient size to stimulate the sense-organ. Below a minimum size, the total amount of energy received by the sense-organ is insufficient to produce the cortical change which results in consciousness.

The third corollary is that the stimulus must last a sufficient length of time so that the total amount of energy received from it shall be of sufficient intensity to cause consciousness.

The fourth and last corollary is that the stimulus must be capable of affecting some of our sense-organs, so that the sensation shall have a certain quality. This is equivalent to saying that a sensory ending must be stimulated, for it will be recalled that each type of sensory ending gives its own peculiar result. Without the stimulation of sensory endings consciousness will not appear.

These four characteristics, quality, duration, extensity, and intensity, have been called the *attributes* of sensation, though it would possibly be better to name them requisite conditions of sensory stimulation. In this way, the necessity of attributing size to a sensation is avoided.

We have previously said that consciousness is composed of a pattern of mental processes. The question now arises: How are we able to discern the differences between them? How can we isolate them and separate them? If they all blend and harmonize so that no outstanding features make discrimination and comparison possible, the result, as the camouflage artists have demonstrated with physical objects, is a blankness, a uniformity of nothingness. Several kinds of contours, markings, or shadings are provided by the very nature of the sensation, by its attributes.

Differences in quality or kind, even in the same family, as red and green, sour and sweet, are to be observed. When representatives of one family are compared with those of another, the differences between qualities are even more striking; there is no mistaking red for sour, or pain for fragrant.

Because of differences of intensity, comparisons can be made between two samples of the same quality, for in-

stance, between two sweets or two reds. Differences in duration help in discriminating two experiences of identical quality and intensity as well as to mark more sharply the distinctions between sensations of differing qualities and intensities. Differences in amount of sense-organ stimulated and the resulting impression of magnitude creates a condition not unlike duration in its effects upon discrimination. These types of differences, taken alone and in combination, enable us to differentiate one sensation from another and so to become aware of the pattern of consciousness.

Discrimination between similar things is aided if they are experienced in close succession rather than simultaneously. At the same time this procedure induces certain constant errors which have to be guarded against. In lifting objects of nearly equal weight, for example, the second is usually judged to be heavier than the first, or at least heavier than it really is.

Usually it is impossible to discriminate in a complex any character which has not been experienced in isolation, or as a part of another complex. If all wet things were cold and all cold things were wet, we should never be able to separate the experiences. But by a sort of mental algebra, when wet things are sometimes cold and sometimes warm; when cold things are sometimes wet and sometimes dry — we succeed in discriminating the experiences one from the other.

This completes our general survey of consciousness. We have tried to describe briefly and name its different characteristics, to explain its origin, and finally to show how consciousness can become aware of its own differ-

ences. Much of the remainder of the book will be devoted to a more detailed discussion of the points briefly mentioned here.

Our method of study may take any of several forms. Three distinct "schools" of psychology have already appeared — the structural, the functional, and the behavioristic. As a result of the considerations already brought out, it is possible for consciousness to take a snap-shot of itself at any instant of time. A moment later another snap-shot can be taken, and the process may be repeated indefinitely. Unfortunately, snap-shot, picture, and pattern are all words suggesting an existence of objects in different places, and the arrangement of objects makes the pattern.

But we have already seen that ideas do not occupy space, so the arrangement of conscious elements cannot be spatial. What we mean is that a scrutiny of the field of consciousness results in discriminations of different qualities and intensities. Duration differences appear only when successive patterns are compared. At any rate, close examination of any particular pattern discloses a relation of conscious elements in terms of quality and intensity. A similar examination of the succeeding pattern will show again a similar relation of elements, and comparison of the two will show changes in the relations and differences in duration of the different processes.

As snap-shots are taken under different circumstances which confront the organism, certain typical differences of pattern may be found. Eventually we may discover, by the use of this method, certain patterns characteristic of the perceptual consciousness, others indicative of the emo-

tional consciousness, still others peculiar to the action consciousness. The offensive instrument for this sort of attack is clearly introspection. Psychologists of this school assert that consciousness may become aware of its own content and describe it as accurately as it senses the physical world and describes it. Introspection, then, is observation of and report upon the phenomena found in the conscious world. This method of approach to psychological problems is called *Structural Psychology*.

It may be inferred that the structural psychologist is compelled to take consciousness for granted, for in no conceivable way can he, from a study of its nature, explain its origin in the individual or in the race. He must assume it to be a universal characteristic of all matter, sticks and stones, as well as human beings, or he must simply take it for granted.

A different and equally obvious approach to the problems of psychology is found in the *functional point of view*. This method, instead of being "still life," is to observe the life history of an idea. Instead of regarding all details of the pattern of consciousness, the functionalists centre their interest upon the more prominent and outstanding elements in the pattern and follow them until they disappear from consciousness. They note changes of intensity, of quality, and shifting relationships with other prominent bits of the pattern. What the "snap-shot" is to structural psychology, the "motion-picture" is to the functional.

Functional psychology owes its existence to the effect of biology upon psychological thought. In the struggle for existence, consciousness appears to be an agent of con-

siderable importance. In some way, it favors survival. Functional psychology is essentially an examination of consciousness as an effect of external stimulation which in turn becomes a cause of more or less intelligent behavior. The functional psychologist believes that consciousness appears when certain rather unusual conditions confront either the individual or the group. It assumes that each animal is born into the world with an equipment of reflexes and instincts which fit him to respond to the usual, customary situations. When novel circumstances develop with which his innate responses are inadequate to cope, consciousness appears and controls the activity until a habit is formed. Then consciousness lapses until another novel situation appears. Consciousness, having tasted the sweets of existence, persists by creating other novel situations which demand its attention.

In part because of the influence of animal psychology, in part because of the difficulty of accounting for consciousness, in part because of the difficulty of relating consciousness and the nervous system, and in part because of the influence of applied psychology, a new contender has appeared which in its extreme form has thrown consciousness away entirely. It is known as Behavioristic Psychology.

Consciousness may be an illusion, it certainly is an inference and an assumption, for we can never prove its existence either in ourselves or in any one else. How a man "feels" when he has a tooth pulled or when he robs a bank is a matter of importance to nobody but the man himself. The important and the only definite consideration, say the behaviorists, is the fact that he responded in a given way under certain conditions. His consciousness

does not add an essential feature to the picture. Even if he has a consciousness, the only way we can know anything about it is through his behavior, including speech. His behavior can be observed and recorded, his consciousness cannot. Therefore let us leave the consciousness out as being irrelevant and immaterial, and concentrate upon the stimulus-response situation. Let us make laws about the responses to certain situations. Then when we know the situation we know what the response will be, and when we wish to induce a certain response, let us create the situation which will call it out. This is the ideal of the behaviorist. Though this attempt may seem, in view of our present knowledge, a little pompous, it yet is one of the ultimate aims of the other two schools, and is not a unique characteristic of the behavioristic movement.

Our method, in the development of this book, will be to take whatever of value we need from the teachings of any or all of the schools.

Summary: Physical energy of many sorts is constantly bombarding the sense-organs. When the energy is of the right sort, is sufficiently intense, enduring, and affects an adequate area of the sense-organ, it causes a physiological change in the sensory nerves. This is propagated from cell to cell in the nervous system until it reaches a muscle or a muscle group. Here it causes contraction of the muscle fibres.

A part of the nerve-current usually goes to the cerebrum, or big brain. When its cells are stimulated by the physiological energy, a psychical change, known as consciousness, ensues.

Since all of the eight classes of sense-organs may be

active simultaneously, the resultant consciousness may be a hodge-podge of differing qualities, intensities, and durations. These differences, which make discriminations and comparisons possible, force certain "patterns" upon consciousness.

Analysis of the patterns reveals two different types of element: the sensation and the affection.

Different ways of considering consciousness have resulted in the development of three different schools of psychology: the structural, the functional, and the behavioristic.

PROBLEMS

1. Distinguish between the physical and the mental.
2. Classify the following as being physical or mental:
   (*a*) The brain.
   (*b*) A sensation.
   (*c*) Air waves.
   (*d*) A mirage.
   (*e*) An intention.
   (*f*) The plot of a story.
3. What are the elements of consciousness?
4. Describe your conscious pattern as it exists now.
5. What is the "cause" of consciousness?
6. What are the attributes of sensation? Try to imagine a sensation without any one of them. What is the result?
7. What factors favor discrimination? What ones favor camouflage?
8. If the "psychological" novel gets its name from the structural psychology, is an adventure story a "psychological" novel from the behavioristic point of view?
9. Describe briefly the psychology of the person going to the dentist from the structural, functional, and behavioristic standpoints.

CHAPTER III

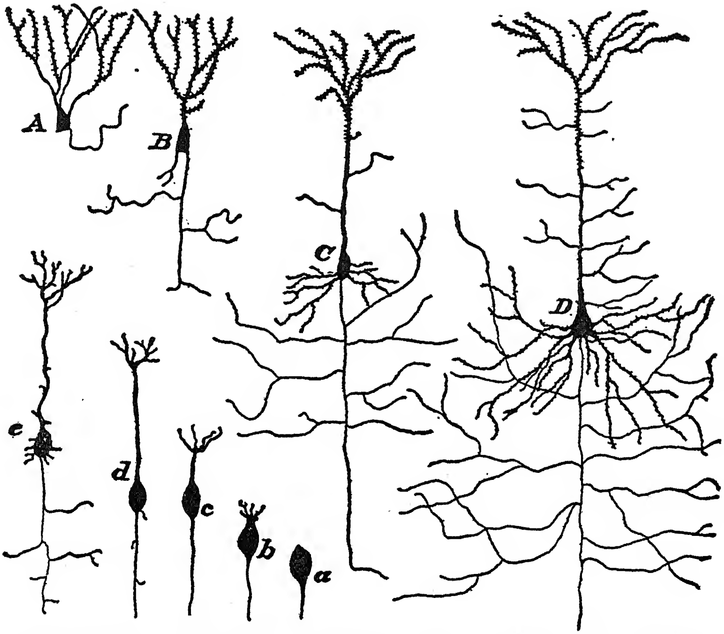
THE SENSE-ORGANS

For many reasons, a more detailed study of the nervous system and of the sense-organs than has already been given is necessary. It has been shown that consciousness is impossible when sense-organs are lacking. It is equally impossible when conduction-lines joining sense-organs to cerebrum are wanting. It is also impossible when the cerebrum, or big brain, is lacking. Furthermore, independent movement of any muscle group is impossible without a nervous system which can carry nervous energy from sense-organs to muscles.

The human nervous system is composed of an almost countless number — estimated at 11,000 millions — of little cells or units known as *neurones*.

These *neurones* are composed of three parts, a relatively large central mass called the *cell-body*, and two kinds of projections, an *axone* surrounded by a sheath, and one or more *dendrites*. At the end of the axone farthest away from the cell-body is a tiny tasselled structure known as the *end brush*.

The nervous system is made up of series of neurones, arranged so that the end brush of the axone of one connects with a dendrite of another. The point of contact between the end brush and the dendrite is known as the *synapsé*. The dendrite is the sensitive part of the structure,



From "Text-Book of Physiology," by William H. Howell. By courtesy of W. B. Saunders Company.

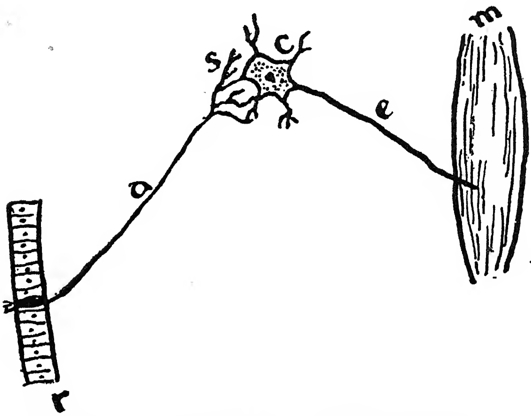
FIG. 1. *A D*, showing the phylogenetic development of mature nerve-cells in a series of vertebrates: *a e*, the ontogenetic development of growing cells in a typical mammal (in both cases pyramidal cells from the cerebrum are shown); *A*, frog; *B*, lizard; *C*, rat; *D*, man; a neuroblast without dendrites; *b*, commencing dendrites; *c*, dendrites further developed; *d*, first appearance of collateral branches; *e*, further development of collaterals and dendrites.—(From Ramón y Cajal.)

the axone the conducting part, corresponding in a general way to a telegraph-wire. As shown in the diagram it is possible for an end brush of one axone to connect with the dendrites of two or more different neurones, in which case there are two or more synapses.

The nerve-current is the energy which when received

from the outside world by the eyes, ears, and other sense-organs, traverses the nervous system, ending eventually in the muscles. It may be likened to a current of electricity in its behavior, though the speed of the nerve current is only 600 feet a second.

Physiologically, the *synapse* is the most important feature



From "Physiology and Biochemistry in Modern Medicine," by J. J. R. MacLeod, M.B. Courtesy C. V. Mosby Company.

FIG. 2. Schema of simple reflex arc; *r*, receptor in an epithelial membrane; *a*, afferent fibre; *s*, synapses; *c*, nerve-cell of motor neuron; *e*, efferent fibre; *m*, effector organ.

of the nervous system. For the direction of the nerve-current is determined by the relative resistance offered to it at the synapses. Let us assume that the nerve-current has a potential of nine units. Synapse *A* offers three units of resistance and synapse *B* ten units. All of the nerve-current not used up in overcoming the resistance of synapse *A* will go over *A*, but none will go over *B*, for the resistance is too great. If the resistance of synapses *A* and *B* are

respectively two and four units, the nerve-current will traverse both synapses, but twice as much will go over *A* as will cross *B*.

There are four general principles concerning the synapse which it is essential to remember:

1. That *use decreases resistance.*
2. That *lack* of *use increases resistance.*
3. That *fatigue increases resistance.*
4. That *cortical action to* the *central side of* a *synapse decreases* its *resistance.*

The nervous system, as related to psychology, may be considered to begin in the sense-organs. Our plan will be then to describe in turn the sense-organs, their nervous parts, and show the route taken by the sensory nerve in going to the brain.

From many standpoints, the most important sense-organ is the eye. It really is a living, self-adjusting camera with a self-renewing film.

As may be seen by a study of the accompanying figure, the "camera-box" is made up of three coats:

I. A tough, leathery, outside coat, called the *Sclerotic.*

(*a*) The front third bulges out to form the *cornea* or white part of the eyes.

(*b*) To the outside of the sclerotic coat are attached the six muscles which control eye movement.

II. A spongy coat called the *Choroid*, which contains many blood-vessels.

(*a*) The front part of this coat is modified to become the *iris*, or colored part of the eye. The hole in its centre is called the *pupil.*

III. The *retina*, which is the sensitive part of the eye, cor-

responds to the film of the camera. This coat will be discussed in detail later.

(*a*) Between the retina and the choroid is a *pigment*

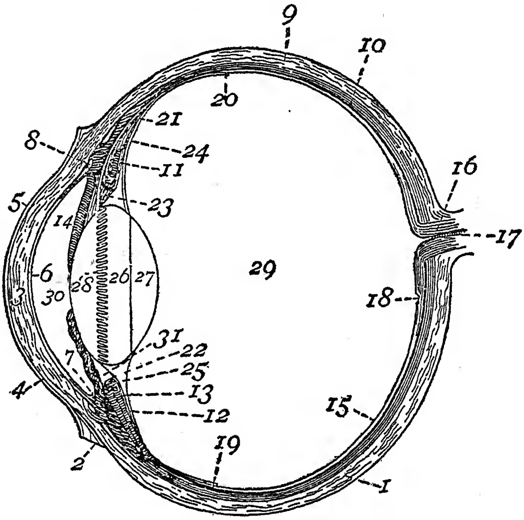


FIG. 3. Diagrammatical section of the eyeball. 1, sclerotic; 2, junction of sclerotic and cornea; 4, 5, conjunctiva; 6, posterior elastic lamina; 7, junction of iris with choroid; 8, canal of Schlemm, a lymph space; 9, pigmented tissue uniting sclerotic to choroid; 10, choroid, 11, 12, 13, ciliary processes; 14, iris touching, but not connected with lens posteriorly; 15, retina lined by hyaloid membrane; 16, optic nerve; 17, central artery of the retina; 18, yellow spot with central groove; 19, 20, anterior portion of retina; 21, junction of choroid and ciliary processes; 22, canal of Petit; 23, free border of ciliary process resting on anterior suspensory ligament of lens; 24, hyaloid membrane; 25, fibres to posterior surface of lens; 26, 27, 28, lens; 29, vitreous humor; 30, anterior chamber containing aqueous humor; 31, posterior chamber communicating with 30.

layer, made up of dark-brown cells. This layer corresponds to the black paint on the inside of the kodak-box. Its function is to absorb the light rays, after they have stimulated the retina, thus preventing radiation.

INTERNAL MECHANISMS

I. One of the important internal mechanisms is the *lens*, which lies immediately behind the iris and the pupil. In structure it somewhat resembles an elastic onion, having a tendency, when unrestrained, to assume an almost spherical shape.

(*a*) It is, however, prevented from doing this by a kind of envelope, the *suspensory ligament*, which surrounds it.

(*b*) This ligament is attached to the *ciliary muscle* in such a way that contraction or thickening of the muscle allows the lens to bulge out, thus increasing its power and bringing the images of near objects to a focus on the retina. Relaxation of the ciliary muscle, on the other hand, compresses the lens, through the action of the suspensory ligament, making it flatten, and hence bringing the image of distant objects to a focus on the retina.

Thus, instead of changing the distance between the lens and the sensitive plate, as is done in the camera, the eye accomplishes the same result by altering the focal power of the lens itself.

II. The eyeball is divided by the lens and its appendages into two parts—an *anterior* and a *posterior* chamber. Both are filled, the anterior chamber with a watery solution, the posterior with a substance having about the consistency of soft gelatine. These two fillers aid in preserving the general spherical shape of the eye.

The entire eye so far is a mechanical contrivance which accomplishes two purposes:

1. It is a self-adjusting machine for bringing the optical image of any object to a focus on the retina, or sensitive plate, thus permitting vision.

2. It serves as a holder or support for the sensory parts of the nervous system which receive energy from the external world.

THE RETINA

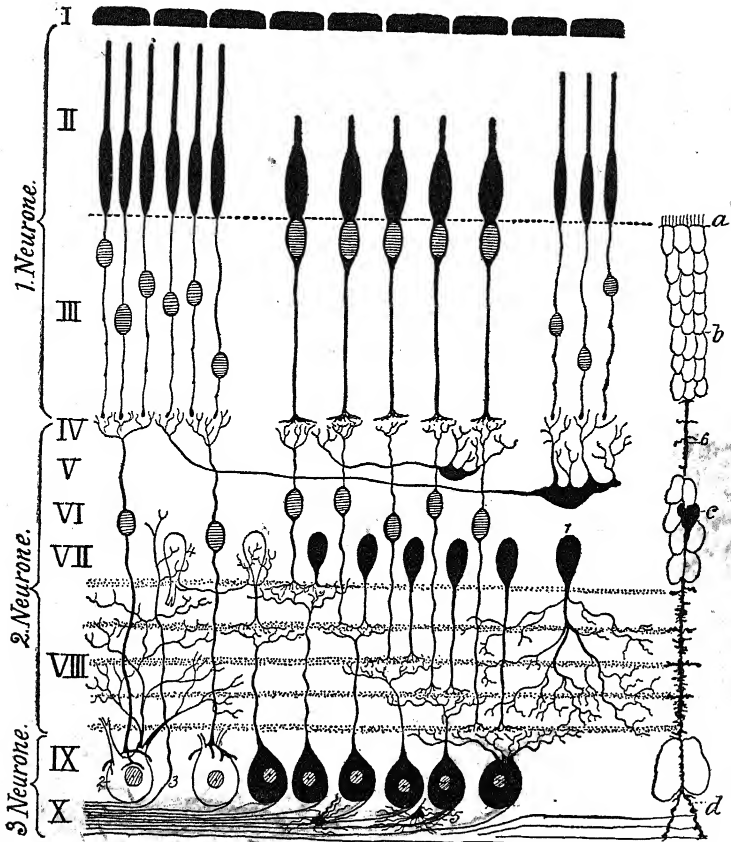
I. The retina, or part of the eye sensitive to light, is not unlike the inside of a tea-cup in shape. In the back of it, directly behind the lens, appears a V-shaped depression, known as the *fovea.* This is the point of clearest vision, and the image of any object clearly and distinctly seen falls upon the *fovea.* The *fovea* is the functional *centre* of the retina; all other parts of this inner coat are called the *periphery.*

II. The nervous elements in the retina are *photochemical* substances, materials set into chemical action by some particular vibration rate of the ether (a hypothetical bearer of light). In the retina are a number of such *photochemical* substances. They appear in two forms — *cones* and *rods.* Both are neurones or nerves which have been modified so as to be sensitive to light.

A. The Cones.

1. *Structure.* In shape the cones (see Fig. 4) are not unlike pine-cones. Each consists of a cell body, a dendrite, which is the cone-shaped structure, and an axone. They are very tiny, many thousands of them being found in a square centimetre.

2. *Distribution.* The cones are densely packed at and near the fovea. As they approach closer to the outer edges of the retina, the greater is the distance between them until at the extreme periphery there are none at all.



From "Text-Book of Physiology," by Howell. By courtesy of W. B. Saunders Company.

FIG. 4. Schema of the structure of the human retina (*Greeff*): *I*, Pigment layer; *II*, rod-and-cone layer; *III*, outer nuclear layer; *IV*, external plexiform layer; *V*, layer of horizontal cells; *VI*, layer of bipolar cells (inner nuclear); *VII*, layer of amacrinal cells (without axons); *VIII*, inner plexiform layer; *IX*, ganglion cell layer; *X*, nerve fibre layer; 6, fibre of Müller.

3. *Function.* There are three classes of cones:

(*a*) The red-green.

(*b*) The yellow-blue.

(*c*) The white-black.

The first two classes derive their names from the sensation which results from their activity. They select different vibration rates to which they respond with different *qualities* of color.

The white-black cones, on the other hand, are set into activity by any stimulus which arouses either the red-green or the yellow-blue cones, but the *quality* of response, *i. e.*, the degree of the blackness or whiteness, is a result, not of the vibration rate, but of the vibration intensity.

(*a*) 1. The red-green cones are found only at and close to the fovéa. The result is that the eye can sense red and green through only a limited range. A red object, for example, seen in indirect vision, that is, so that the image falls upon a peripheral part of the retina, will stimulate, not a red-green cone, for there is none there, but certainly a white-black cone, and possibly a yellow-blue one, if any yellow or blue is mixed with the red. This region of the retina, in which red and green can be seen, is known as the *first zone.*

2. In certain abnormal cases, the red-green cones are lacking, with the result that neither red nor green can be seen. This condition, known as *Red-Green Blindness,* is an inherited affliction which occurs in about four per cent of men and one-half of one per cent of women.

(*b*) 1. The yellow-blue cones extend from the fovea in all directions about sixty degrees, being intermingled with the red-green cones in the first zone and extending farther

toward the periphery. The region of the retina between the outer limits of the red-green cones and the outer limits of the yellow-blue cones is known as the *second zone.* In this region, the eye is red-green blind, but can see yellow-blue, black-white, and any of their combinations.

2. A few cases of *yellow-blue* blindness have been discovered. This disorder, of very rare occurrence, is evidently a result of the overuse of drugs, which temporarily paralyzes the action of the yellow-blue cones.

(*c*) 1. The white-black cones extend over the entire retina. That region beyond the limits of the second zone is known as the *third zone.* In it no colors are seen, only black and white.

2. No cases have been reported in which the red-green and yellow-blue cones were absent throughout the eye with the black-white present.

(*d*) Color mixture. When the two-color substances in the cone are stimulated equally at the same time, the result is a condition essentially the same as no action. But in these circumstances, the white-black cone is to be pictured as active. Consequently the result of such mixture is gray, and colors which combine to produce gray are called *complementaries.*

When two colors, not complementaries, are mixed, the result is a compromise. The relations are shown in the diagram on the following page.

Colors may also be mixed with grays. The result is when mixed with black, a shade of the color; and when mixed with white, a tint.

(*e*) *After-images.* When the eye has been exposed to a stimulus for a while, certain after-effects may appear.

These are of two sorts, depending upon the duration of the stimulus.

1. *Positive after-image.* If the stimulus has been of brief duration, an after-effect can be noticed which is like

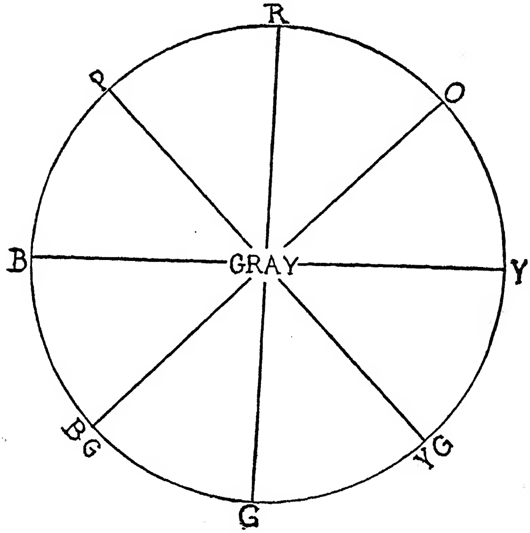


FIG. 5. Colors opposite by a whole diameter are complementary and when mixed give gray. Colors opposite by less than a whole diameter give when mixed an intermediate color in the short arc of the circle.

the stimulus in quality and brightness. This is known as a positive after-image and is due to the physical principle of inertia acting in the cone.

2. *Negative after-image.* If the stimulus is of longer duration, fifteen seconds or more, the after-effect is just opposite to the stimulus in both quality and brightness.

The explanation is that the cone has to retain a con-

dition of chemical equilibrium. If the red portion has been largely decomposed when the stimulus is removed, the structure is "top-heavy" on the green side, so there is an automatic decomposition of the green substance in the effort to regain equilibrium. A similar condition exists in the black-white cone.

B. The Rods.

1. *Structure.* The rods are long, spindle-shaped, modified dendrites, which extend farther toward the choroid coat than do the cones. They have, like the cones, a cell body and an axone. In cross-section they are even smaller than the cones.

2. *Distribution.* The rods are closely packed at the periphery, but decrease in frequency toward the centre, until at the fovea there are no rods at all.

3. *Function.* (*a*) The rods, in one respect, are similar to the white-black cones, for they are stimulated by all vibration rates, responding only with colorless sensations of white, black, and gray.

They are different from the cones, however, for while the cones are most sensitive to yellow light, the rods are most responsive to those vibration rates which lie in the green and greenish-yellow regions of the spectrum.

(*b*) The rods are much more sensitive to light than the cones; in some cases needing only one five-hundredth as much energy to stimulate them. This makes them ideal for

(*c*) *Night vision.* Since so great an intensity of light is necessary to stimulate the cones they are practically blind in late twilight and darkness. Whatever vision exists, under these conditions, is the function of the rods. Night-

seeing animals and birds, such as bats and owls, are supposed to be equipped only with rods. Because of the very great sensitivity of these structures, daylight is too intense and glaring for their eyes, and they are practically blind during the day.

(*d*) There is still another reason for this. For the rods to function it is necessary that a substance known as *visual purple* be formed. In the pigment layer between the choroid coat and the retina are certain cells which act something like glands. The stimulus that makes them work is lack of light. The result of their activity is the secretion of tiny, minute granules, like flakes of pepper but much smaller, which are purple in color. This is the *visual purple.*

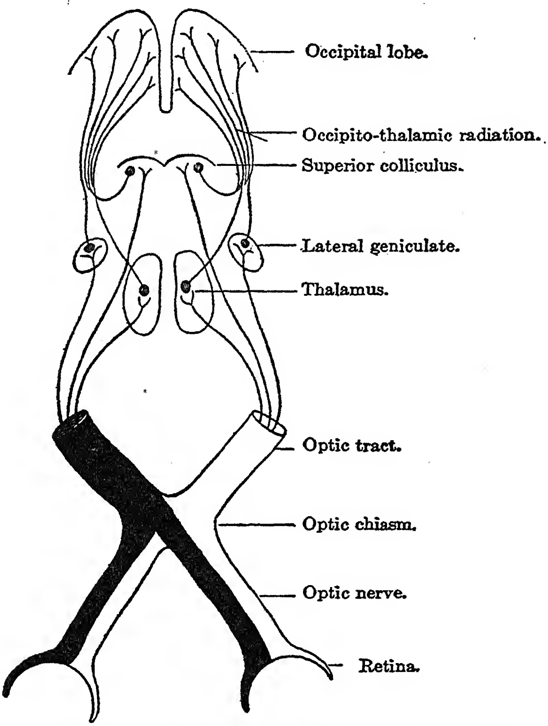
It collects about the ends of the rods nearer the choroid coat, and in some way aids the rods to perform their visual duties. The visual purple forms slowly but is bleached rapidly by exposure to light.

(*e*) When the cones are lacking entirely or are functionally out of commission so that the rods are the only visual instruments, a condition of *total color-blindness* results. The person possessing this form of disorder sees no colors at all — nothing but whites, grays, and blacks, though the so-called black has a somewhat bluish tinge.

THE OPTIC NERVE

The rods and cones, essentially modified neurones, send their axones forward to connect with a second group of neurones, the *bipolar* cells, which also lie in the retina. These, in turn, connect with the large *ganglion cells*, which constitute the third layer of the retina. The axones of the

ganglion cells, running over the surface of the retina like the threads in a rug, come together to form the optic nerve



From "Text-Book of Physiology," by Howell. By courtesy of W. B. Saunders Company.

Fig. 6. Diagram to indicate the general course of the fibres of the optic nerves and the bilateral connection between cortex and retina.

and pass backward through the three coats of the eye at a place known as the *blind spot.* The pathway to the brain is shown diagrammatically in Fig. 6.

THE EAR AND HEARING

The ear is a mechanical instrument whose function it is to transform vibrations of the air into vibrations of a fluid, which in turn affect the *hair*-cells, the beginnings of the *auditory nerve*.

The ear consists of three parts:

1. The outer.
2. The middle.
3. The inner.

I. The outer ear in turn is made up of two parts:

(*a*) The concha or shell, which possibly serves to collect and focus air vibrations into

(*b*) the *external meatus*, a slightly curved passageway leading inward toward the middle-ear.

II. The middle-ear — essentially a cavity in the bone of the head — opens, by way of the *Eustachian* tube, into the throat. This tube, which opens every time one swallows, thus permitting the passage of the air in either direction, serves to equalize the air pressure on both sides of the *ear-drum*, a condition necessary for free vibration of the drum.

(*a*) The drum is a membrane separating the outer and middle ears. As will be seen in the diagram:

(1) It is set on the bias.

(2) It is concave with reference to the outer ear.

Made up of both radial and concentric fibres, it is loosely stretched across the opening. Having no vibration rate of its own, as it would if tightly stretched, it is capable of being swung in and out by any vibration rate which is received by the external ear. Such vibration is transmitted to the

(*b*) Chain of bones, which passes across the upper part of the middle-ear.

The *hammer*, attached at the lower end to the *drum*, and at the upper to the *anvil*, is moved by every vibration of

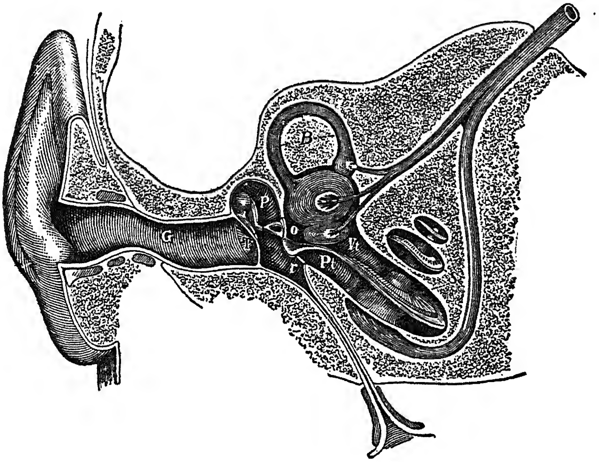


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FIG. 7. Semidiagrammatic section through the right ear (*Czermak*): *G*, External auditory meatus; *T*, membrana tympani; *P*, tympanic cavity; *o*, fenestra ovalis; *r*, fenestra rotunda; *B*, semicircular canal; *S*, cochlea; *Vt*, scala vestibuli; *Pt*, scala tympani; *E*, Eustachian tube.

the drum. The *anvil*, fastened at its point of rotation to the bony wall of the middle-ear, thus becomes part of a bent lever system. An inward movement of the lower end of the hammer therefore causes a similar inward movement of the lower projection of the *anvil*. This in turn is passed on to the *stirrup*, the third bone in the series. The inner end of the stirrup connects with the inner ear.

This chain of bones makes up a bent lever, the fulcrum being near the point of attachment to the upper wall of the middle-ear. The hammer arm of this lever is one and one-half times as long as the arm made up of the anvil and stirrup. Hence the amplitude of vibrations is reduced and the force increased—a very necessary precaution when it is realized that the inner ear is filled with a liquid which is not so easily set into vibration as is the air.

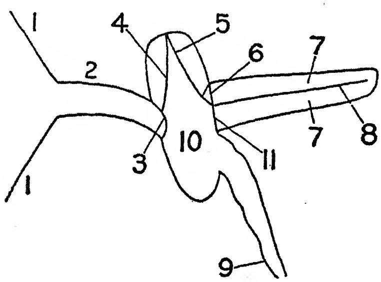

FIG. 8. Diagram illustrating the Mechanics of the Ear:

1. Concha of External Ear.
2. External Meatus.
3. Drum.
4. Hammer.
5. Anvil.
6. Stirrup.
7. Cochlea Uncoiled.
8. Basilar Membrane and Bony Shelf.
9. Eustachian Tube.
10. Middle-ear.
11. Round Window.

The air waves are caught by the concha of the external ear and directed into the external meatus. When they reach the drum, the air waves set it into vibration. The vibratory movement of the drum causes an oscillation of the three bones which make a bent lever. The stirrup fits into the cochlea. When the stirrup vibrates it causes a vibration of the fluid which fills the cochlea. The movement of this fluid in some manner stimulates the hair-cells, thereby starting a nerve current.

III. The inner ear is contained in another cavity in the bone of the head. This cavity contains a structure which, from its resemblance in shape to a snail-shell, is called the *cochlea*. Two openings are found between the middle and inner ears.

(*a*) The upper, the *oval window*, receives the stirrup, which fits into it and vibrates back and forth like the piston in a cylinder.

(*b*) The lower, the *round window*, which constitutes the exit, is covered with an elastic membrane. The membrane has two functions.

(1) Since the cochlea is filled with a watery fluid, the membrane serves as a cork and prevents leaking.

(2) Since the liquid is practically incompressible, the elasticity of the membrane allows vibration of the fluid to take place. Since the cochlea is wound up on itself two and one-half times, following the course of the vibration is difficult. Imagine therefore that it is uncoiled and stretched out straight. It will then look like the diagram, Fig. 8.

The whole mechanism so far is a device for transforming air vibrations, collected by the external ear, forwarded thence by way of the drum to the bony lever, into vibrations of the fluid in the cochlea. To show how such an agitated liquid is capable of stimulating the auditory nerve, it is necessary to study the cross-section of the cochlea. Imagine that it is cut across and turned so that you look into the cut end.

CROSS-SECTION OF COCHLEA

In cross-section the cochlea is seen as a nearly circular tube which is divided into three canals by two partitions.

1. *Reissner's membrane* divides the upper half into two parts.

(*a*) The *scala vestibuli*, the canal connected with the *stirrup*, is filled with the fluid called *perilymph*.

(*b*) The *canal of the cochlea*, filled with *endolymph*, is entirely separated from the other canals.

2. The horizontal partition is made up of two parts:

(*a*) The bony shelf, which extends over approximately to Reissner's membrane; and

(*b*) The *basilar* membrane.

(1) Looking down on top of the basilar membrane it is seen to be made up of fibres which are stretched across the cochlea. These fibres vary in length from .04 millimetre at the base of the cochlea near the oval window to .48 millimetre at the apex. The basilar membrane has then the appearance of a triangle about 33 millimetres long with a base of .48 millimetre.

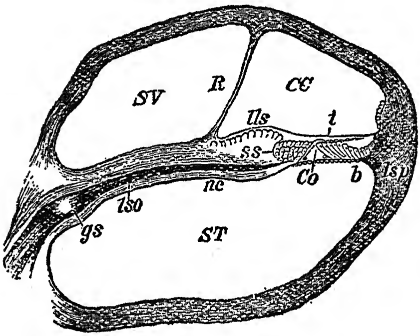

FIG. 9. Section through one of the coils of the cochlea (diagrammatic). *SV*, scala vestibuli; *ST*, scala tympani; *CC*, canal of the cochlea; *lso*, lamina spiralis ossea, or spiral plate of bone; *lls*, limbus of the spiral lamina; *R*, Reissner's membrane; *ss*, spiral sulcus or groove; *t*, tectorial membrane; *CO*, organ of Corti; *b*, basilar membrane; *lsp*, spiral ligament; *nc*, cochlear nerve; *gs*, spiral ganglion in course of cochlear nerve.—(After Henle.)

(2) Sighting along the top of the basilar membrane as along the barrel of a gun, several other structures are seen.

(*a*) A triangular cavity or hole made by two little structures, known as the *Rods of Corti*, which meet at the top.

(*b*) On each side of these are the *Hair-Cells* — the nervous part of the ear and the beginnings of the auditory nerve. One or two hair-cells are found toward the centre of the cochlea from the rods of Corti, and four or five are found on the side opposite. The hair-cells, like the rods and

cones of the retina, may be regarded as modified dendrites, which constitute the real beginnings of the auditory nerve.

The path traversed by the axones is indicated in Fig. 12.

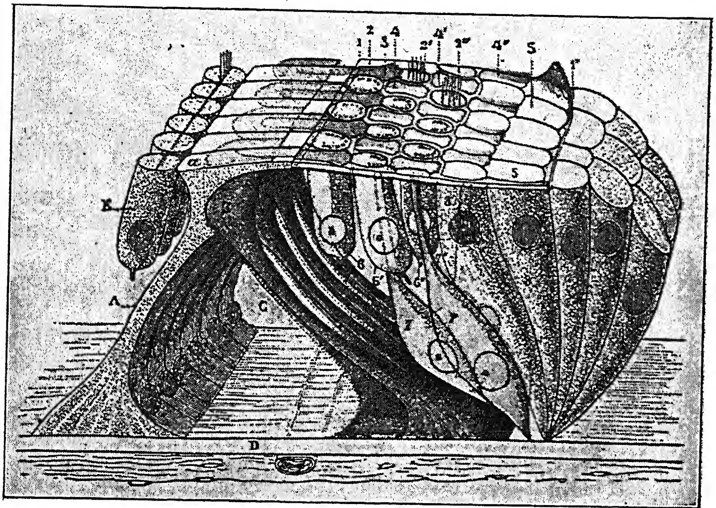

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FIG. 10. Diagrammatic view of the organ of Corti, the sense-cells and the accessory structures of the membranous cochlea (Testut): *A*, inner rods of Corti; *B*, outer rods of Corti; *C*, tunnel of Corti; *D*, basilar membrane; *E*, single row of inner hair (sense) cells; 6, 6′, 6″, rows of outer hair (sense) cells; 7, 7′, supporting cells of Deiters. The ends of the inner hair-cells are seen projecting through the openings of the reticulate membrane. The terminal arborizations of the cochlear nerve-fibres end around the inner and outer hair-cells.

The auditory system consists of three parts:

1. A transmitter, the ear, whose function it is to

(*a*) Collect air vibrations;

(*b*) Transform them into vibrations of the fluid in the inner ear;

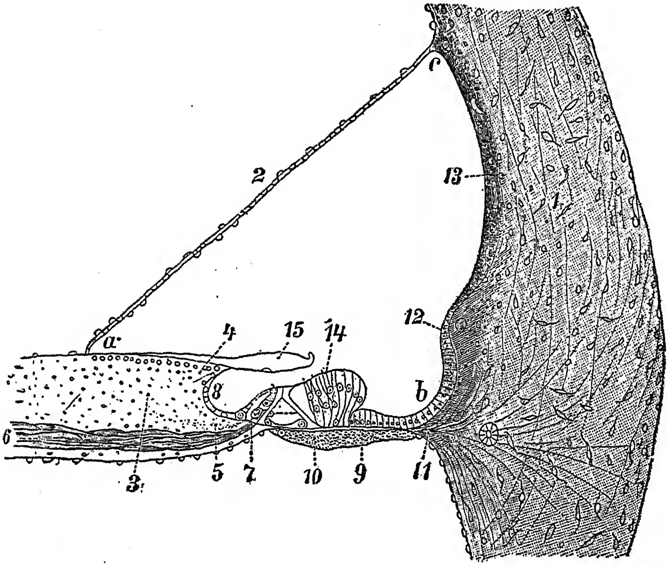

FIG. 11. Cross-section of the human cochlear duct at the junction of the first and second turns of the cochlea, × 100. 1, Outer wall (part of the spiral ligament) reaching from *b* to *c*; 2, vestibular wall, or Reissner's membrane, from *a* to *c*; tympanic wall from *a* to *b*; 3, lamina of bone; 4, its vestibular lip; 5, its tympanic lip; 6, nerves of hearing passing to epithelium at 7; 8, internal spiral groove with flattened epitheluim; 9, basilar membrane; 10, its tympanic covering; 11, basilar crest of spiral ligament; 12, prominence of spiral ligament with blood-vessel; between 11 and 12, the external spiral groove; 13, vascular layer; 14, spiral papilla (epithelium of Corti's organ); near 14, the outer hair-cells and Deiter's cells; farther inward, the rods of Corti covering the tunnel; internal to this, the inner row of hair-cells; 15, the tectorial membrane.—(After Retzius.)

(*c*) Stimulate the hair-cells:

(1) By the oscillatory movement of the liquid into which the hairs project and

(2) By the vibration of the strands of the *basilar membrane* upon which the hair-cells rest.

2. A conducting apparatus, which consists of the sensory neurones leading from the ear to the brain.

3. A receiving station, situated in the *temporal* lobe of the brain, in which the stimulation is translated into consciousness, an awareness of the sound made by some external object.

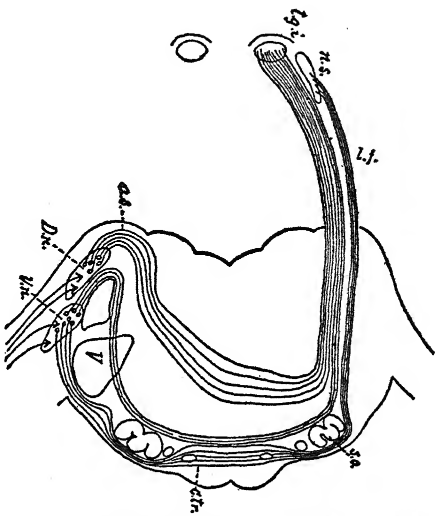

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FIG. 12. Diagram to show central course of auditory fibres (modified from Van Gehuchten): *D.n.*, Dorsal nucleus giving rise to the fibres that form medullary striæ (*a.s.*); *V.n.*, the ventral nucleus, giving origin to the fibres of the corpus trapezoideum (*c.tr.*); *s.o.*, superior olivary nucleus; *l.f.*, lateral lemniscus; *n.s.*, nucleus of the lateral lemniscus; *t.g.i.*, the inferior colliculus.

AUDITORY PHENOMENA

The physical cause of sound is usually air vibrations.

1. When these vibrations are *fast* they set into *sympathetic vibration* the shorter fibres of the basilar membrane and produce a sound of *high pitch*. On the other hand, when they are *slow* they affect the longer fibres and produce a sound of *low pitch*.

2. When the vibrations are of considerable *amplitude* they cause a marked displacement of the fibres of the basilar membrane, which results in a *loud* tone; slight amplitude,

on the other hand, causes but a slight stirring of the fibres, and this is accompanied by a tone of slight intensity.

3. The form of the vibration affects the quality of the sound.

(*a*) Periodic and rhythmic vibrations produce tones.

(*b*) Aperiodic or mixed vibrations produce noises.

TASTE

The sense-organ of *taste* is the tongue. If one will look at a convenient specimen he will see that it is dotted, particularly near the edges, with bright pinkish spots about the size of the head of a pin.

TASTE PAPILLÆ

These structures, known as *taste papillæ*, are essentially little pits in the tongue. Substances taken into the mouth and there mixed with saliva are carried into these pits where they come into contact with the modified dendrites of the *taste nerves*.

1. *Distribution*. The taste papillæ are lacking on the mid line of the tongue, but are fairly numerous around the edges.

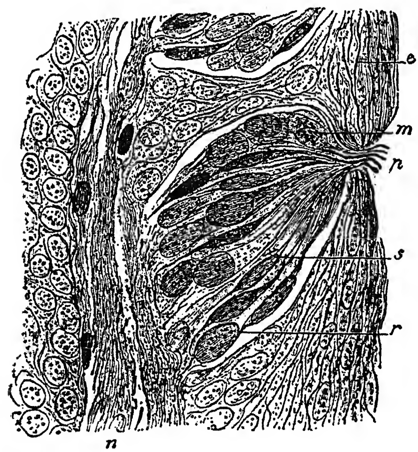

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FIG. 13. Section through one of the taste buds of the papilla foliata of the rabbit (from *Quain*, after *Ranvier*), highly magnified: *p*, Gustatory pore: *s*, gustatory cell; *r*, sustentacular cell; *m*, leucocyte containing granules; *e*, superficial epithelial cells; *n*, nerve-fibres.

2. *Structure.* Shaped like a water-jug with the neck toward the surface of the tongue, these papillæ are filled with little spindle-shaped cells from the tops of which

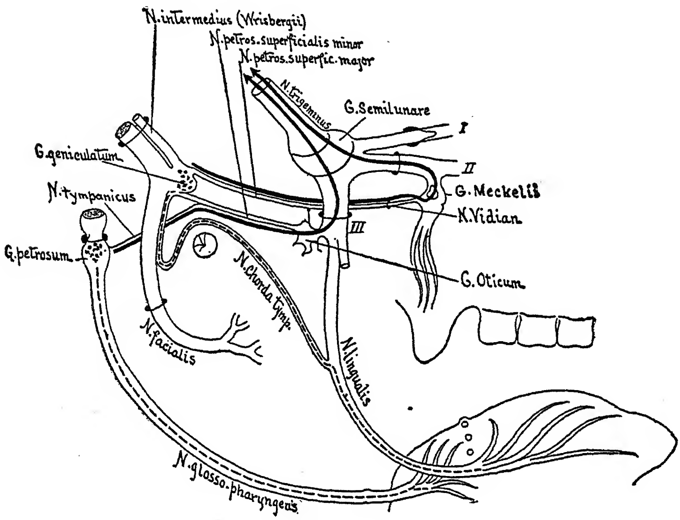

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FIG. 14. Schema to show the course of the taste fibres from tongue to brain.—(*Cushing.*) The dotted lines represent the course as indicated by Cushing's observations. The full black lines indicate the paths by which some authors have supposed that these fibres enter the brain in the trigeminal nerve.

project a few hair-like filaments. These are the modified dendrites of the *taste nerves*. Each papilla contains from twenty to thirty such cells.

3. *Function.* The spindle-shaped cells are of four kinds — those which are sensitive respectively to:

(*a*) Sweet.

(*b*) Salt.

(*c*) Sour.

(*d*) Bitter.

These four tastes are the only ones to which the human being is sensitive. There are, of course:

(*a*) Mixtures of tastes with tastes.

(*b*) Mixtures of tastes with odors which give the flavors of the foods and drinks taken into the mouth.

(*c*) Mixtures of tastes with the cutaneous qualities (to be discussed shortly) — cold, warmth, pressure, pain, and their complexes, such as roughness-smoothness, coarseness-fineness, etc.

THE TASTE NERVES

Two sensory nerves run from the taste papillæ — one serving those in the front two-thirds of the tongue, the other those in the posterior third — to the brain region on the mesial or inner surface just above the *corpus callosum*. The course of these nerves may be traced in the accompanying figure.

SMELL

The sense-organ of smell is the nose, and the stimulus is the odoriferous particles which are carried in the air.

As will be seen in Figure 15, the cross-section of the nose discloses three channels — a lower, a middle, and an upper — in the turbinate bone. In ordinary normal breathing the air is carried principally through the lower channel, but some going through the middle. When the inhalation is more forceful, more of the air is carried through the middle passage, thus being brought into closer contact with the dendrites of the nerve of smell, shown at the point *O* in the diagram.

This *olfactory region*, about the size of a five-cent piece, is made up of a vast number of dendritic processes, which penetrate the bone from above.

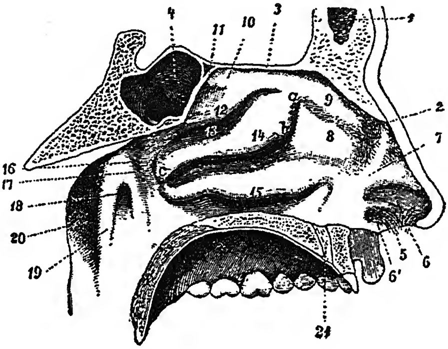

FIG. 15. Outer side of left naris. 1, Sinus or hollow in the frontal bone; 2, free border of the nasal bone; 3, lamina cribrosa or perforated plate of ethmoid bone through which pass the twigs of the olfactory nerve; 4, antrim or hollow of the sphenoid bone; 5, hairs in the vestibule of the nose; 6, 6′, vestibule of the nose separated by a prominence, 7, from 8, the entrance to the middle meatus or passage of the nose; 9, agger or mound of the nose, the rudiment of a muscle; 10, concha or shell of Santorini; 11, entrance to 4; 12, superior spongy bone; 13, upper meatus; 14, middle spongy bone; its inferior free border from *b* to *c*; 15, inferior spongy bone; 16, naso-pharyngeal fold; 17, naso-pharyngeal duct; 18, pharyngeal opening of the Eustachian tube; 19, fold between; 20, depression of Rosenmüller; 21, the incisor canal.—(Schwalbe.)

These dendrites are of several kinds, as is shown by the following proof. After one's nose has been constantly exposed to a particular odor for a period of time, it can no longer smell it. This, a result of the thorough fatigue or exhaustion of the receiving dendrites, is known as smell exhaustion.

If, while the nose is thus exhausted for one odor, another is smelled, any of four results may occur:

1. We may be unable to smell the second odor, which means that it is normally sensed by the dendrites now exhausted, and hence belongs to the same class as the first.

2. The intensity of the second odor may be reduced,

showing that its detection depends in part at least upon the dendrites already fatigued, and that the odor belongs to a neighboring class.

3. The second odor may be unchanged, showing that no relation exists between it and the first.

4. The second odor may be intensified, showing that it belongs to a contrasted class.

As a result of such an analysis, Zwaardemaaker worked out nine classes of odors:

1. Ethereal smells, including fruit odors.
2. Aromatic smells, *e. g.*, camphor, spice.
3. Fragrant smells, *e. g.*, many flowers: violets, sweet peas, etc.
4. Ambrosiac smells, *e. g.*, musk.
5. Alliaceous smells, *e. g.*, garlic, chlorine.
6. Empyreumatic smells, *e. g.*, burning tobacco, burned toast, coffee.
7. Hircine smells, *e. g.*, cheese.
8. Virulent smells, *e. g.*, opium.
9. Nauseous smells, *e. g.*, decaying animal matter.

Unfortunately classes 6 and 9 seem to be based, not on smell exhaustion, but upon other considerations. In class 6 the basis of similarity appears to be certain cutaneous qualities which are common to the odors, and in class 9 the similarity seems to be the physiological reaction called out by the odors..

There is, however, good evidence of the existence of at least seven classes of smells, and consequently of at least seven different kinds of dendrites, one for each class.

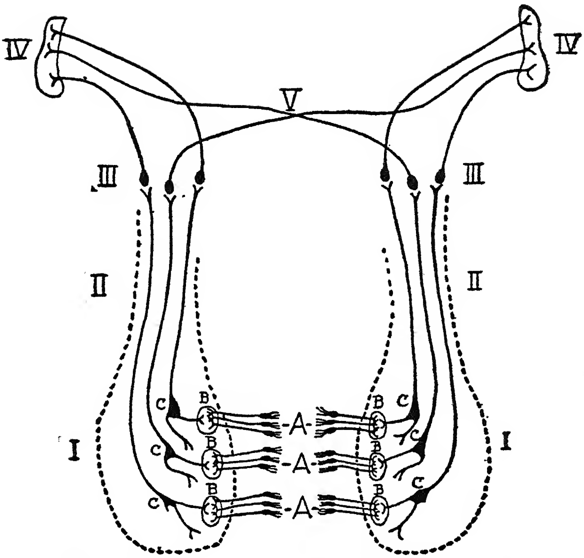

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FIG. 16. Diagram of olfactory paths: *I*, Olfactory bulb; *II*, olfactory tract; *III*, olfactory area on base of brain; *IB*, olfactory cortex (uncinate gyrus); *V*, anterior commissure; *A*, olfactory epithelial cells in nose; *B*, glomeruli in olfactory bulb; *C*, mitral nerve-cells. The fibres from the mitral cells end in nerve-cells in the olfactory area, whence their path is continued by a third neurone to the cortex of the uncinate gyrus on the same side and possibly also by fibres crossing in the anterior commissure to the hippocampal cortex on the other side.

THE OLFACTORY NERVE

The olfactory nerve, beginning in these olfactory cells, goes to the olfactory bulb, and from thence to the olfactory cortex, as shown in Figure 16.

CUTANEOUS SENSATIONS

In the skin are a number of different kinds of modified dendrites. In general, they resemble a ball filled with a

tangle of yarn, the yarn corresponding to the dendritic portion of the neurone and the ball to a capsulated structure whose function it is to magnify the physical stimulus.

These structures are scattered through the skin in much the chance order and arrangement of salt and pepper shaken on eggs.

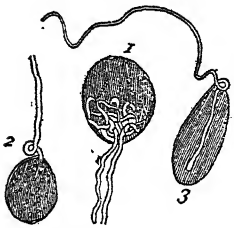


FIG. 17. Various forms of end-bulbs.— (Krause.)

Four general types of modified dendrites are found:

1. The end bulbs of Krause, which are responsible for our sensations of *cold*. They can be stimulated by:

(*a*) Temperatures below twenty-eight degrees Centigrade.

(*b*) Temperatures above forty-five degrees Centigrade.

(*c*) Certain chemicals such as menthol.

(*d*) Pressure.

(*e*) Electricity.

These end bulbs, situated about midway through the dermis or true skin, are quite prompt in their response to stimulation.

It must be understood clearly that these sensitive structures are sparsely scattered through the skin — about thirteen to the square centimetre, or eighty to the square inch — and that only those parts of the skin immediately above such structures are sensitive to cold.

This fact is demonstrated by cooling a rod to slightly above the freezing-point and then drawing the pointed end slowly over the surface of the body. Occasionally cold will flash out as the result of the stimulation of the underlying end bulb of Krause. This point should be noted and marked

in red. Continue this until a square inch of surface has been explored.

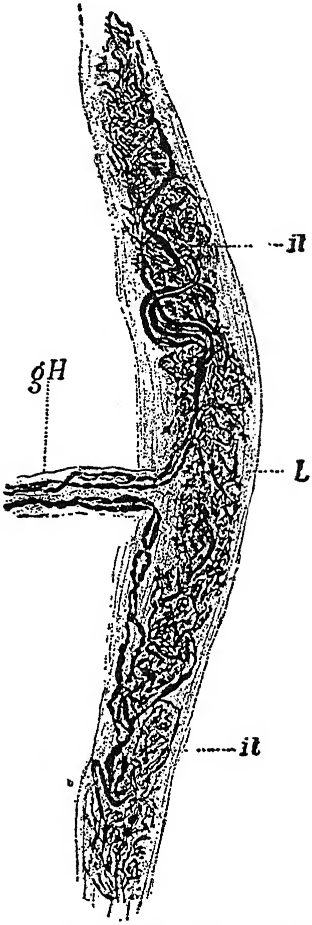
(1) You will notice seventy to ninety of the red dots, scattered at random, which mark the position of the underlying nervous organs.

(2) You will notice, also, that cold occurs only in spots, which are called *cold spots*.

(3) You will discern, also, that many of these spots can be stimulated by the other methods suggested above.

2. The *Ruffini* cylinders are responsible for sensations of *warmth*. These structures are deeply imbedded in the skin, and the stimulus — temperature above thirty-four degrees centigrade — takes some time to reach them. Warmth is consequently a sluggish sense.

An experiment similar to that performed on cold spots, except that now a rod heated to forty-five degrees centigrade is used, will disclose the existence of *warmth spots*.



From Dunlap, "An Outline of Psychobiology." By courtesy of The Johns Hopkins Press.

FIG. 18. A Ruffini's nerve ending. Highly magnified. — (Barker, "Nervous System," after Ruffini.) The ramifications of the nerve-fibre *gH* are enclosed in the connective-tissue capsule *L*.

These are of rare occurrence, only eight to fifteen being found in a square inch.

3. *Pressure sensations* are obtained from the stimulation of two different kinds of nervous structures:

(*a*) *Hairs.*

(*b*) *Meissner* corpuscles.

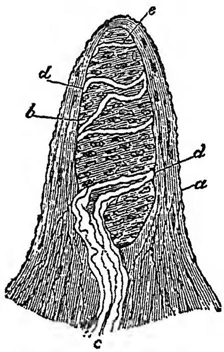


FIG. 19. Touch corpuscle. *a*, Layers of connected tissue of the true skin; *b*, body of corpuscle; *d*, *d*, nerve-fibres twisted spirally round the corpuscle; *c*, nerve-fibres at the lower end of the corpuscle; *e*, nerve-fibre ending in little thickening near the upper end of the corpuscle. Magnified 50 diameters.

A. Of the entire surface of the body, ninety to ninety-five per cent is more or less completely covered with hair. The individual hairs, whose tops penetrate the skin at an angle of some sixty-five to seventy degrees, have roots which are wound about by modified dendrites. The projecting portion of the hair therefore operates as a lever; whenever it is displaced, either from side to side or by pulling or pushing, pressure is exerted upon the dendrites surrounding it and a pressure sensation results.

B. The *Meissner corpuscles* (Fig. 19), found primarily in the hairless areas of the body, such as palms of the hands, forehead, lips, etc., yield *pressure sensations* indistinguishable from those received by way of the hairs.

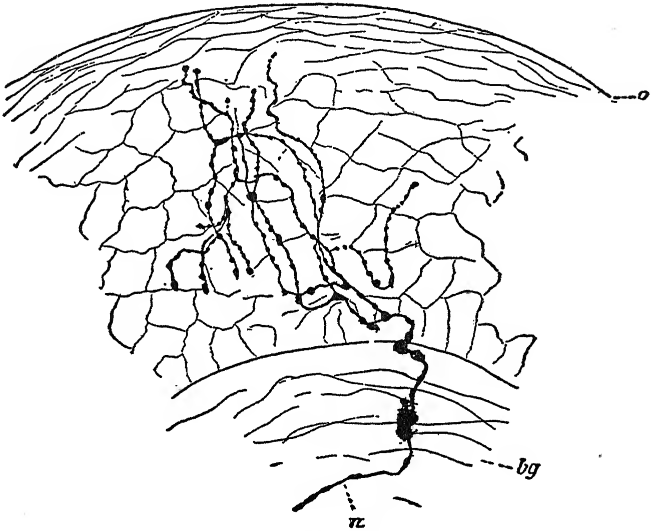
4. *Pain.* Sensations of pain divide into three classes:

(*a*) Cutaneous pain.

(*b*) Sense-organ pain.

(*c*) Internal pain.

A. Cutaneous pain, like pressure, warmth, and cold, appears only in *spots*. These spots are much more numerous than with the other cutaneous senses, from 500 to 600 being found to the square inch. By far the greatest number are found in the tiny, minute wrinkles or creases in the skin, and at the intersection of two such creases a pain spot is almost certain to be discovered.



From Dunlap, "An Outline of Psychobiology." By courtesy of The Johns Hopkins Press.

FIG. 20. Free nerve-endings in the epithelial lining of the æsophagus of a rabbit. Highly magnified.—(Barker, "Nervous System," after Retzius.)

The modified dendrites which respond to pain are called *free nerve-endings*. (Fig. 20.) They lie very close to the outer surface of the dermis, sometimes being found in the epidermis.

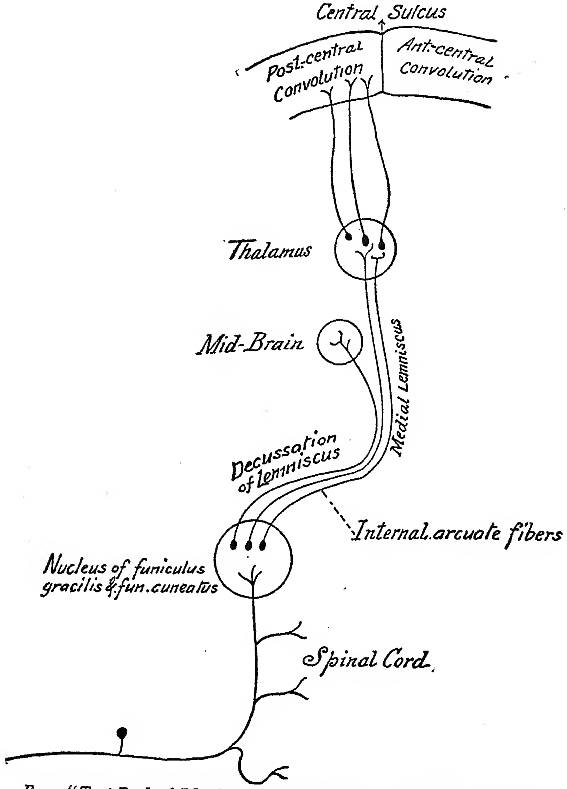


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FIG. 21. Schema representing the origin and course of the fibres of the median fillet—the intercentral paths of the fibres of body sense.

Pain is a "slow" sense, slower even than warmth. The reason, while not definitely settled, may be the very round-about conduction pathway to the brain.

The normal stimulus for cutaneous pain is intense pressure.

B. Excessive stimulation of any sense-organ — a flash of lightning or a loud sound close at hand — arouses pain sensations. It is probable that in these sense-organs are to be found special *pain nerves*, similar to those found in the skin and yielding the same kind of sensation when stimulated.

The stimulus, however, instead of being limited to intense pressure, is probably *any abnormal condition* or any intensity of stimulation which may be injurious to the structure.

C. Concerning *internal* pain little is known except the fact of its existence. It is probably caused by abnormal conditions of some kind, which if not rectified will prove harmful.

KINÆSTHETIC SENSATIONS

Penetrating down between the *muscle-fibres* and ending in little knobs so that the whole structure resembles on a small scale a bunch of currants, are the modified dendrites of the neurones which give rise to the *kinæsthetic sensations*, the sensations received from the muscles.

Whenever a muscle contracts, its fibres shorten and thicken, with the result that these little knobs are squeezed. The pressure acts as a stimulus, and the resulting nerve-current, when carried to the brain, affords knowledge of the amount of contraction of the muscle.

A similar mechanism is found in the *tendons*.

These *kinæsthetic sensations* are seldom noticed, being used primarily as a *part* of the system for *automatic* control of movement, together with *sensory impulses* from the vestibular part of the ear (to be discussed presently).

In learning *new* movements, however, the kinæsthetic

sensations have an important rôle to play, so that an understanding of what they are and how they are produced is of considerable value.

STATIC SENSE

The inner ear consists of two parts:

1. The cochlear division, concerned with hearing, already discussed.

2. The vestibular part, concerned with the *Static sense*. Three distinct structures are employed by this sense:

A. The Sacculus.

B. The Utriculus.

C. The Semicircular Canals.

A and *B*. The Sacculus and the Utriculus are essentially two connected boxes, lined with hair-like modifications of sensory dendrites, filled with fluid, and containing a number of tiny, minute pebbles. These, by force of gravity, are brought into contact with the lower sides of the boxes, thus stimulating the nerve. Which side of the box is lowest depends upon the position of its owner; when standing erect it is one side, when standing on his head it is another.

Inertia likewise plays a part, for as the body starts forward the little pebbles, like the passengers on a street-car, tend to lag behind, striking the dendrites and thus stimulating the nerve.

C. The *semicircular canals* are three little tubes curved into an approximate half-circle. They open into the utriculus and are filled with the same kind of fluid contained therein.

If one stands in one corner of a square room and faces

the corner diagonally opposite, he has one *semicircular canal* in the plane of the floor, one in the plane of the end wall, and one in the plane of the side wall.

At the end of each of the canals is an enlargement, into which project the hairs connected with the modified sensory dendrite. Whenever the head is turned from side to side, inertia causes the liquid in a semicircular canal to lag behind, thus causing a current opposite to the direction of head movement. This current deflects the hairs in the enlarged portion, thus stimulating the nerves and causing a nerve-current.

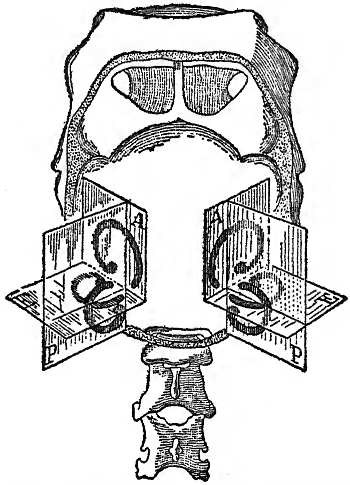

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FIG. 22. Diagram to show the position of the semicircular canals in the head of the bird. On each side it will be seen that the three canals lie in planes at right angles to one another. The external or horizontal canals (*E*) of the two sides lie in the same plane. The anterior canal of one side (*A*) lies in a plane parallel to that of the posterior canal (*P*) of the other side.—(Ewald.)

These three structures together are stimulated by:

1. Position of body.
2. Position of head.
3. Change of position of body.
4. Change of position of head.

As with the kinæsthetic sensations, the stimulations from these nerves affect consciousness little if any, but do serve in part as automatic regulators of movements — especially those concerned with maintaining equilibrium.

ORGANIC SENSATIONS

Of the considerable number of sensations coming from inside the body, *hunger* and *thirst* are the ones which have been most thoroughly studied.

Hunger is the name attached to the sensations which follow fasting. However, they do not last for long. The sensations are due to the contractions of the walls of the stomach, being strongest when such contractions are strongest.

Thirst results from the drying of the membrane in the back of the throat.

This completes the sensations, a group which certainly is not large. Yet these sense-organs form the only contact between the individual and the world in which he lives; they are the only sources of information.

WEBER'S LAW

Since in the discussion which follows we shall attempt to indicate as fully and definitely as possible the exact relationship existing between the different physical stimulations and the resulting ideas and actions, it will be well to start at the very beginning of the entire discussion and state as clearly and lucidly as possible *Weber's Law*.

Weber's Law is a statement of the relationship which exists between the *intensity* of the *stimulus* and the *intensity* of the resulting *sensation*.

For the sake of illustration we shall use pressure sensations. Imagine that you are sitting at a table with your left hand resting upon it, palm down, and that your eyes are closed. A second person places gently upon the back of

this hand a tiny piece of cork. Its physical energy, being too slight to stimulate the nerves, produces no sensation of pressure. By gradually increasing the weight of the cork, however, it is possible to secure a sensation which can just be detected. This first sensation is called the *liminal sensation*, and the stimulus necessary to produce it is called the *liminal stimulus*.

Having determined these two, the next step is to increase the weight of the bit of cork until a sensation is produced, which is just noticeably different from the first one. Again the weight of the cork is increased until a third sensation intensity appears which is just noticeably different from the second. These processes may be continued indefinitely until the weights used become extremely painful. In this way are secured a series of sensation steps, 1, 2, 3, 4, . . . n, and also the actual weights which are necessary to bring about these different sensations.

It will be seen, as shown in Figure 23, that when the sensation increases in an arithmetical progression, the stimulus increases in a geometrical progression. This indicates very strikingly that in order to increase the intensity of the sensation it is necessary to increase more than proportionately the intensity of the stimulus which causes that sensation. In the arithmetic series each term except the first is formed by the addition of a constant to the preceding number of the term, whereas in the geometrical progression each term except the first is obtained by multiplying each succeeding term by a constant.

It is important that these facts be kept in mind when the discussion of effects of certain objective conditions upon attention are being studied, for we find that prac-

tically all of the factors approximate Weber's Law. While it is true that Weber's Law does not hold strictly at either end of sensation-intensity series, yet it has been found to

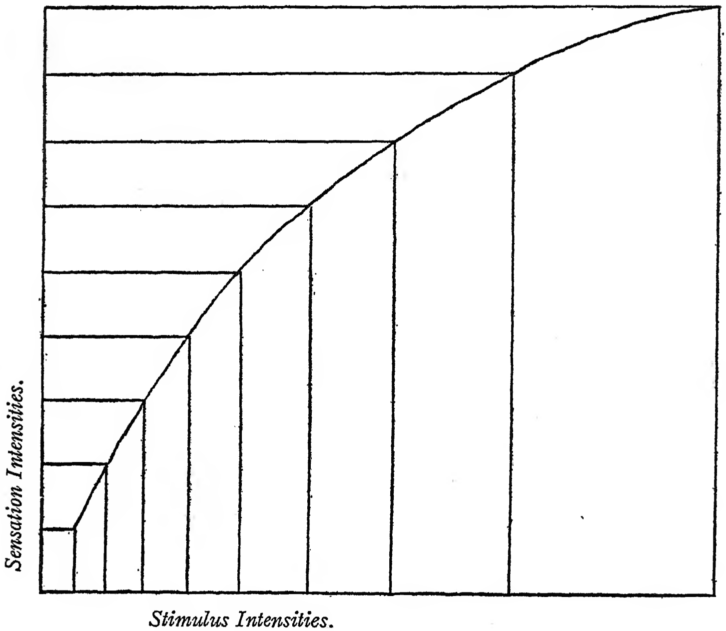


FIG. 23. Illustrating Weber's law. As the sensation intensities increase equally, or by an arithmetical progression, the stimulus intensities increase by a geometrical progression.

hold fairly definitely and fairly accurately throughout the middle ranges.

Naturally the constant which is used in determining the geometrical progression of the stimulus series is different for each sense department. This ratio is ordinarily expressed in terms of a fraction. For example, when it is

said that the fraction for lifted weights is one-fortieth, it means that starting with any sensation intensity, in order to obtain another sensation which is just noticeably greater than the first, it is necessary to increase the stimulus which produced the first sensation by one-fortieth of its absolute weight.

Exactly the same description will hold for other sensations, and this series is the measure of the keenness of the discrimination of the different senses. A few examples will serve to illustrate this point.

Passive pressure	1/3
Lifted weights	1/40
Visual length of lines	1/50
Visual discrimination of brightness	1/100
Intensity of sound	1/5

Doctrine of Specific Nerve-Energies. — According to psychological usage, stimuli are of two kinds — adequate and inadequate. When the stimulus and conscious quality agree, as for example, a cold stimulus resulting in a cold sensation, the stimulus is said to be adequate. On the other hand, when the stimulus produces an unnatural and uncorrelated conscious quality, as a hot stimulus giving a sensation of cold, the stimulus is said to be inadequate. The observation that the sensation resulting from both adequate and inadequate stimuli is the same — that the arousal of any single sensory ending, no matter how it is stimulated, gives the same conscious quality — has been known as the doctrine of specific nerve-energies.

Summary: Analysis reveals the existence of seven sensory structures, the only doors between mind and the outer

world. Owing to the fact that the ear is a double sense-organ, eight different groups of experience are possible:

Visual.
Auditory.
Olfactory.
Gustatory.
Cutaneous.
Kinæsthetic.
Organic.
Static.

Possible experiences are consequently determined in large part by the existence of these sense-organs and their ability to play their normal part.

Each sensory ending "knows but one word" and shouts it or whispers it at the command of the external world. This situation raises a fundamental question for all knowledge. Are the form and content of our information determined by the external world, or by our sense-organs, or by our brains? Or does each in turn play its part so that at last the brain is the determining structure? Is it true, as James suggests, that if the auditory and optic nerves were severed and the outer end of each joined to the inner end of the other, that we should see sound and hear light?

PROBLEMS

1. Why should you be asked to study the sense-organs and nervous system in a course in psychology?
2. In how many ways can two neurones be joined together? Which of these ways permits the passage of the nerve current from one to the other?

3. What is the synapse? Why is it important? Give the laws of action of the synapse.
4. Draw a diagram of a rod and a cone. Which end of the rod or cone is turned toward the pupil of the eye? Does the rod or the cone extend farther toward the choroid coat?
5. What is the negative after-image of red, yellow, green, blue, orange, purple? In the second zone of the retina, what is the negative after-image of purple? Of orange?
6. Compare the vision of the third zone of the retina with rod vision.
7. How is the air-wave transformed by the ear into vibrations of a fluid? How does the vibrating fluid stimulate the hair-cells?
8. Analyze the "taste" of coffee; of ice-cream; of chicken; of hot tea; of cold tea.
9. Do equal amounts of increase of intensity of stimulus produce equal amounts of increase of intensity of sensation? Are just noticeable differences in sensation necessarily equal differences?
10. What determines the quality of the sensation — the stimulus, the sense-organ, or the area of the cortex stimulated?

CHAPTER IV

THE NERVOUS SYSTEM

FROM the foregoing discussion of the sensations, their special organs, and the pathways they take, it is apparent that we are dealing with a problem in transportation — the routes followed by sensory impressions and the terminals which they reach. When the terminal, the cortex of the brain, is reached, the different impressions scatter, some going one place, just as the passengers do, some another, and enter into a group of different relations.

In the examination of the different routes, a few names have appeared again and again:

1. The medulla.
2. The corpora quadrigemina.
3. The thalamus.
4. The cerebellum.
5. The cerebrum.

Keeping the railway figure, these structures correspond to the important cities through which the transportation lines pass.

These structures have three main functions:

1. They are the naturally important places through which the transportation systems pass.

2. They are junctions, where a passenger can change from one system to another.

3. They are places also where inter-city transfers can be made.

The different terminals reached, like the different stations, are matters of local geography. The sensory areas in the brain are shown in the diagram, Figure 25.

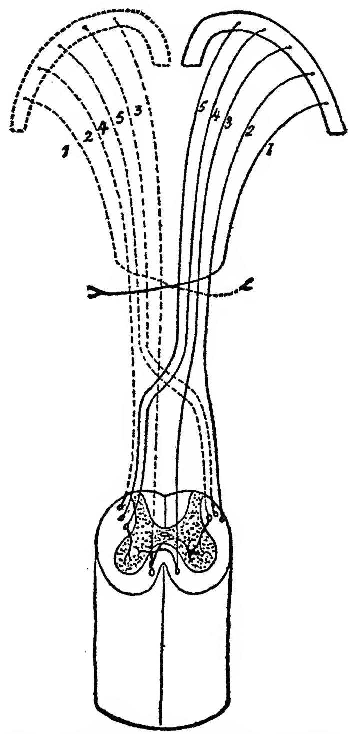
It will be noted that there are two large areas which up to the present have been given no function. These are:

1. A large one in front, composed of:

(*a*) The *motor* area, to be discussed presently.

(*b*) A *Frontal Association* area.

2. A smaller one, surrounded like an island by the visual, auditory, cutaneous, and other sensory regions.



From "Text-Book of Physiology," by Howell. By courtesy of W. B. Saunders Company.

FIG. 24. Schema representing the course of the fibres of the pyramidal or cerebrospinal system: 1, Fibres to the nuclei of the cranial nerve; 2, uncrossed fibres to the lateral pyramidal fasciculus; 3, fibres to the anterior pyramidal fasciculus crossing in the cord; 4 and 5, fibres that cross in the pyramidal decussation to make the lateral pyramidal fasciculus of the opposite side.

THE ASSOCIATION AREAS

These association areas may be likened to the inter-city transfer lines — street-cars, subways, elevated railroads, taxis.

Their function is to interconnect the different brain regions.

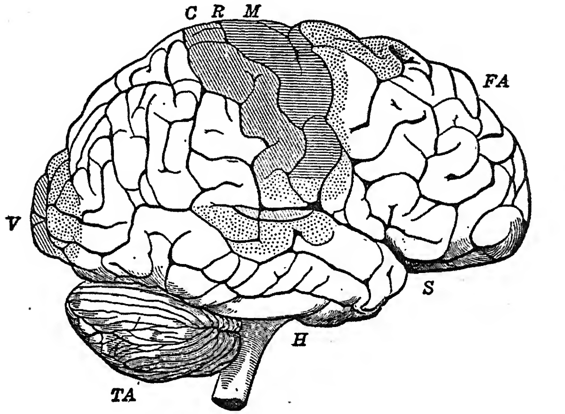
1. The *posterior* association area has two distinct functions.

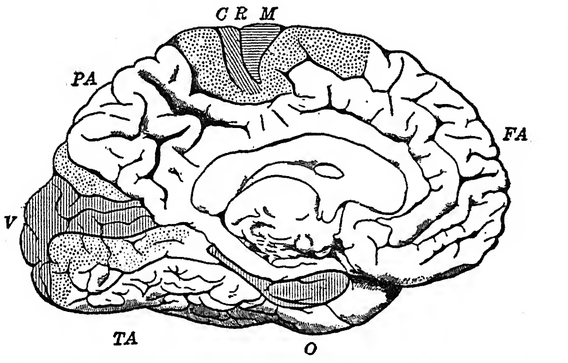
(*a*) One is to interconnect the different sensory areas of the brain. The importance of this may not at first glance be apparent, but analysis will disclose it.

Each sensation tells merely one fact about an object — gives one quality, as for example, it shows that an apple is red. That is all the information to be derived from one sensation. Another will tell us that it is sweet, another of its coldness, a still different one of its odor, etc. Each is one way of considering an apple, but none of them is the apple. The apple is a real thing; each sensation received is but one of its qualities or characteristics. So the real thing, the apple = red + sweet + ethereal + a lot of other qualities + the knowledge that they come from the same object. The knowledge of real objects, such as are those of the real world in which we live, demands that the different sensations be associated, fused together, and organized — conditions made possible by the posterior association area.

(*b*) To connect the sensory areas with the motor area is the second function of the *posterior association area*. The need for this type of connection is more obvious, for it is self-evident that information can be of no practical value if we cannot adjust our conduct to take advantage of it.

2. The *frontal* association area, experimental evidence indicates, is concerned with the formation of *new habits*. Whether this area is the centre for intelligence, for our





From "Fundamentals of Psychology," by Pillsbury. By courtesy of The Macmillan Company.

FIG. 25. Localization of cerebral functions. The upper figure shows the outer surface of the right hemisphere; the lower figure, the mesial surface of the left hemisphere. In both figures the motor areas are marked by horizontal shading, the sensory by vertical shading, while the associatory areas are unshaded. The doubtful or partially sensory and motor areas are dotted. *S* is opposite the fissure of Sylvius; *R*, above the fissure of Rolando. On the mesial surface the parieto-occipital fissure is just above the shaded portion marked *V*; *M* is above the motor area; *C*, above the cutaneous and kinæsthetic area; *V* indicates the visual area; *O* is below the olfactory area. The auditory area is just below the fissure of Sylvius, above *H*. *FA* designates the frontal; *PA*, the parietal, and *TA*, the temporal association areas. There is some evidence that the dotted areas about the sensory and motor areas are areas in which particular associations are formed for the corresponding sense or movements. (The diagram embodies the results of A. W. Campbell, but has been modified in one or two respects to agree with the results of Flechsig and Cushing.)

finest ideals, for our most subtle sentiments is debated. That it is definitely related to our ability to learn to run a typewriter, to become expert in juggling, and similar acts of skill, is highly probable.

THE MOTOR NEURONES

Previous sections have shown how the sensory neurones connect with the sensory regions of the brain and how the different sensory areas are interconnected by association neurones.

But in addition to this the sensory areas must be connected with the motor region so that it is possible for us to act in response to our information. The association fibres connecting with the motor region come in contact with large pyramid-shaped cells in the motor area just in front of the fissure of Rolando.

The axones of these cells extend downward and connect with other motor neurones which eventually terminate in the muscles.

The connection of the motor area of the brain is both *direct* and *indirect*.

1. The *direct* pathway. In this, the axones penetrate downward through the white matter of the brain until they reach the medulla. Here the bundle of axones divides into two parts: a larger, forming the *crossed pyramidal pathway;* and a smaller, the *direct pyramidal pathway.*

The crossed pathway, in the medulla, crosses over to the opposite side of the nervous system and runs down through the spinal cord. Finally the fibres enter the gray matter of the cord where they terminate, their end branches connecting with the *anterior horn cells* of the cord.

The *direct* pyramidal pathway does not cross in the medulla but continues downward through the spinal cord on the same side. When the axones arrive at the level from which they are to emerge, they plunge into the gray matter of the cord and cross to the opposite side, coming in contact with the *anterior horn cells*.

No matter whether an impulse is carried by the *direct* or the *crossed* pathway, it arrives at the same place, the anterior horn cells of the opposite side. This means that the left side of the brain controls the right side of the body and vice versa. *Right-handed people are left-brained.*

The axones of the *anterior horn cells* run out to the muscles. Penetrating down into the muscle-fibres, they end in little flattened structures known as *muscle-plates*.

The nerve-energy carried to the muscle-plates causes the muscle to contract, thus causing a movement.

2. *The indirect pathway*. On its way down, the direct pathway gives off certain fibres to:

1. The cerebellum.
2. The thalamus.
3. The corpora quadrigemina.
4. The medulla.

In these structures, it will be remembered, certain sensory axones end, connecting with other sensory axones which continue the pathway toward the brain.

But these sensory axones also connect in many places with motor neurones, so that mechanical adjustments can be made to stimulations not requiring conscious control. It is at the same time necessary that consciousness, by way of the cerebrum, should be able to control the same muscle either in the same or in a different way.

This is accomplished by having fibres from the cerebrum connect with the motor nerves starting in the cerebellum, thalamus, etc.

Because of this arrangement, each group or segment of the nervous system acts as a relatively independent department, yet is at the same time, under the direction of the commander, the cerebrum.

In the spinal cord, for instance, a vast amount of routine adjustment to incoming impressions is made. These responses are so mechanical, so frequent, and so stereotyped that there is no occasion to call in the aid of the commander in making routine decisions. Yet at the same time, he has direct and individual authority over this department as over all others.

This frees his time for making the more important decisions, for planning, for considering new business, etc. Yet should anything go wrong in any of the departments, the cerebrum is immediately notified by the incoming sensations and can give whatever orders are necessary.

Summary: The nervous system for psychology begins in the sense-organs. Here highly specialized nervous structures are set into activity by physical energy. The physiological energy thus caused flows through parts of the nervous system until it eventually comes to a muscle. Sometimes the energy goes to the brain, sometimes it does not. Should it arrive at the cerebrum, consciousness follows.

PROBLEMS

1. Why is a connection between sensory and motor brain regions necessary?
2. What advantages arise from the interconnection of the sensory areas of the cerebrum?

3. In how many different ways can you explain blindness? deafness?
4. What are the nervous pathways involved in kicking a football? in throwing a baseball? in writing a letter?
5. Show how the same movements may be initiated and controlled separately by the cord, medulla, cerebellum, thalamus, and cerebrum.

CHAPTER V

RETENTION AND ASSOCIATION

If the raw materials of knowledge be sensations, or qualities, an interesting and fundamental question immediately arises. How do we get our knowledge of things? For it is clear to the most casual observation that the adult unit of knowledge is to be found in the object, not in the sensation. In fact, the sensation, for the adult, is an abstraction arrived at through analysis of objects and their relations. The answer is that, as far as consciousness is concerned, the object is an assembly of unit parts which are sensations. As is the case in a factory, the parts waiting to be put together may be inside the building, or they may be hauled in from other sources. In consciousness, the situation is similar. The elements to be assembled may be brought in from the external world by way of sensation, or they may be taken from the stock of memories and images on hand, a procedure which greatly facilitates and speeds up the work of putting together.

We shall now examine the methods whereby sensations and memories are assembled to give an awareness of the object. We shall try to indicate the binding mechanisms which take the place of physical bolts, screws, rivets, mortices, and glue in holding the assembled product together. This binding mechanism is found in the association process.

A particular mental process can remain in consciousness

for a comparatively brief time; it then dies out and disappears. It can be rearoused at some future time. Where has it been in this interval between our first and second impressions of it? It cannot have existed in the form of a mental process because a mental process is necessarily conscious. The idea disappears as an idea, but it leaves as an after-effect certain changes or modifications in the nervous structure. We believe that a sensation is the result of the stimulation of a certain particular group of nerve-cells in the cortex of the cerebrum. The sensation is evoked when the nerve-current flows through these cells. A different sensation involves the action of a different group of nerve-cells. The effective cause of the sensation is the passage of energy derived from the outside world through the cells.

Whenever energy traverses a physical medium it produces some change in the substance through which it flows. Since the nerve-current is a form of physical energy, it will in passing modify those parts of the nervous system which it traverses. It may be well to pause a moment and review the various effects of the passage of the nerve impulse through the nervous matter so that they shall be fresh in our minds for the discussion to follow. Whenever a stimulus from the outside world affects a sense-organ it produces, or may produce, four very different results, as follows:

1. It sets the sense-organ into activity.

2. It starts a nerve-current which usually goes, in part at least, to the cerebrum. Here it arouses consciousness and we become aware of the stimulating quality.

3. It goes to one or more muscle groups, causing their contraction and therefore movement.

4. All the way through its course in the nervous system, from sense-organ to muscle, it leaves after-effects behind it.

Since a particular sensation is the result of the passage of the nerve-current through a certain group of cells, it is not improbable that the modifications left behind should be as unique as the experience itself. Since both are pertinent effects of the same cause, it is not unnatural to think of them as related in some way. In other words, we believe that the modification is peculiar to the sensation, different sensations leaving behind different modifications.

We are now in a position to answer the question: Where are our ideas when they are not in consciousness? The answer is, they do not exist in the form of sensations, or ideas, but have a *potential* being in the modifications remaining in the nervous system. For when another nerve-current, derived from any source whatever, flows over one of the brain regions which has been thus modified, a re-arousal of the sensation originally present when the modifications were made ensues.

The principle is very similar to that of the dictating-machine. When one speaks into the instrument, he causes a vibration of the diaphragm. To this is attached a sharp point which ma es a scratch or groove, peculiar to the sound uttered, in the rotating cylinder. The sound is not stored in the cylinder. Yet by exchanging the sharp needle for a blunt one and running over it the groove made when the record was fashioned, the original sound is reinstated.

The action going on inside the nervous system is very similar to this. Without the brain, or at least some plastic substance, there would be no retention and no recall. The two basic factors are the modifications left in the nervous

substance by previous experiences, and the nerve-current which again traverses the modified brain region. This nerve-current must start in some sense-organ, for it cannot originate elsewhere. Its course, after it leaves the sense-organ, is determined by the relative resistance of the nervous pathways over which it might go.

For the present purpose we may picture the nervous system as made up of pathways, or lines of discharge of nervous energy. These pathways are even more complicated than the arrangements of telephone-wires, but they accomplish a similar purpose in that each sense-organ is connected by an intricate system of paths with all the response organs in the body. This is accomplished by the "junctions" between pathways, which make complex interconnections possible. The greatest complexity of the conduction systems and also the greatest number of junctions is found in the cerebrum.

One peculiarity of the pathway which demands immediate attention is the fact that it always offers resistance to the passage of the nerve-current; and the nerve-current always goes over the pathway offering it the least resistance. The different brain regions connected by easily traversible pathways are said to be *associated.* Just what sensation shall be recalled, then, is a matter of association, a topic which must be discussed in considerable detail.

The most fundamental of all psychological principles is the law of association. To know psychology, the understanding of this law is imperative. In this connection, the word association is used in its customary sense to mean a condition of being together, of being connected, or of being related. Therefore, association is a bond or connection be-

tween two or more things. What things are associated? Three possibilities suggest themselves at once: objects, ideas of objects, brain regions whose activities yield the ideas of objects. A little thought shows that objects cannot, in the psychological sense, be associated, for they are known only through conscious experience. Nor can the ideas of objects be associated, for the association may endure longer than the idea. The idea is momentary, transient, the association relatively permanent, and it is against common sense to expect a permanent connection between transients. The suggestion revolts our notion of probability. The brain regions involved in the ideas of objects are relatively permanent, they are connected by physical pathways, and so satisfy the conditions which must be met in explaining association.

Since association is a neural process, it will pay us to extend a trifle our knowledge of the nervous pathways already mentioned. The pathways may be considered as beginning in the sense-organs and extending toward the cerebrum. Bypaths connect the sense-organ with the various muscles. Arrived at the brain, these pathways meet others which serve first to interconnect very thoroughly and intricately the sensory regions of the brain, while, secondly, other pathways connect the sensory brain regions with the motor areas. From the motor areas, other pathways extend toward the muscles. Those pathways leading in a direction from sense-organ toward brain are known as sensory, those extending from brain toward muscles are known as motor, and those interconnecting sensory regions and also those connecting sensory with motor regions are known as association pathways.

Furthermore, we have observed that the pathway always offers resistance to the passage of the nerve-current. It is probable that the resistance occurs at the junctions rather than in the clear paths themselves, but since no path is without junctions the more general statement may be used. When one pathway connects with two others, as it may well do, two junctions exist. Which of these two shall be traversed by the nerve-current leaving the first path depends upon the relative resistance occurring at the junctions, for the nerve-current takes the easier pathway. These junctions are known technically as *synapses*.

Several conditions affecting the resistance of the synapse may be described as follows:

1. Use decreases resistance.
2. Disuse increases resistance.
3. Fatigue increases resistance.
4. Action in a given group of brain-cells decreases resistance in the pathways leading to the active region.
5. The nerve-current is delayed or slowed up at the synapse, the amount of slowing varying proportionately with the amount of resistance.

We now have the knowledge of the nervous system necessary to explain the formation of associations. The fundamental problem of association is: How do two brain regions which are active simultaneously, or at least have a temporally overlapping activity, become associated? In other words, how and why does the nervous activity spread from one brain region to the other? The situation may be represented by an actual illustration. While walking along the street with John Smith, I hear a bell ringing. Glancing about I locate it in the steeple of the Methodist

church. An auditory impression is followed by a visual one and the two tend to become associated, so that subsequently when I hear the sound of the bell the picture of the steeple tends to follow it. Yet the sound of the bell does not become associated with the physical appearance of John Smith, nor with the remarks he was making just before or just after the bell rang.

Describing the situation neurologically and using algebraic symbols for the sake of brevity, the conditions are as follows: A nerve-current coming from the auditory organ arouses a group of cells, M, into activity; another and a different nerve-current coming from the eyes arouses a different group of cells, N, which may lie some distance from M in the brain. How does the togetherness in time of the action of these two regions connect them? It does and consequently the how and why of such connection becomes our immediate problem.

Our task then reduces to explaining how and why two nervous regions, M auditory and N visual, active together or in immediate succession, tend to become connected by pathways of low resistance; while M and X, the appearance of John Smith, the latter being relatively inactive, do not become similarly connected.

Three cortical regions, M, N, and X, will be assumed. M and N are to be considered as stimulated by external energy, X as unstimulated. Between these three regions pathways of high resistance already exist, for it will be recalled that all sensory regions in the brain are interconnected. These pathways lead from M to N, from N to M, from M to X, from X to M, from N to X, from X to N. It is necessary to assume a double-track system of connec-

tions between the regions, for a single pathway can conduct in only one direction. Concretely, then, our problem consists of explaining how the resistance in the pathways M to N and N to M is reduced when M and N are simultaneously active, whereas the pathways connecting M with X and N with X maintain their original high resistance if region X is inactive.

We know, from the previous discussion, that the nerve-current tends to continue on its way from the sense-organ to the muscle. Consequently when it arrives in region M it must go onward, its course being determined by the relative resistance of the synapses encountered. From M, in our picture, it will tend to spread toward both N and X. When N in turn is stimulated, its energy will likewise tend to spread to M and X. In both cases, just as much energy goes over the MX and NX as over the MN and NM pathways and consequently use will reduce the resistance in all pathways equally. The mere forward spreading or radiation of nerve-energy, therefore, cannot account for the formation of associations.

If we search further among our laws of nervous action for a principle which can be used for this purpose, we find the following: When any nervous region is active, the resistance in the pathways leading toward it is decreased. Apply this to our present problem and it is easy to see that with M and N both active simultaneously, the resistance in the pathways interconnecting them is reduced, thus favoring an interchange of energy between them. Because X is inactive, the resistance in the pathway leading to it from both M and N is unchanged. It is consequently higher than in the M to N and N to M pathways. Since

the nerve-current follows the pathway offering the least resistance, it flows from M to N and from N to M. Because use decreases resistance, the result is that these pathways tend to have a permanently lowered resistance and an association has been formed.

It is inevitable that the intensity of nervous action in the two regions should be a conditioning factor of the formation of associations, for the greater the intensity of action, the greater will be the effect upon the resistance in the pathways leading to the region involved. For the same reason, simultaneity of action is an essential condition of the formation of associations, for, after the region is stimulated, the energy tends to flow onward, thereby decreasing in intensity the activity of the region.

We find, then, that when two brain regions are strongly active, either together or in immediate succession, pathways of low resistance between them tend to be formed. The consequence is that when another nerve-current coming from any source arrives in region M, awakening the idea involved in the activity of that region, the current, going the easiest way, will flow over to region N, arousing it to activity with the inevitable ideational result. This is a simple act of recall and all recall is the result of the use of associations which have been formed at some time in the past.

What now are the physical conditions favoring association? If we are to have two experiences actually together or close together, the juxtaposition of objects in space is advantageous. This type of association, of experiences derived from objects contiguous in the external world, is known as *contiguity*. Similarly, a succession of events is

also favorable and association because of this condition is known as *succession.* It is perfectly safe to say that all associations are formed either by contiguity or succession, when these two terms are understood to apply to the physical relationships of the objects which cause the experiences. We ordinarily use the single word contiguity to include succession more for the sake of brevity than for any other reason. *Similarly, we use the expression association of ideas, knowing full well that not ideas, but brain regions, are associated, to save circumlocution and awkwardness of expression.*

All association is formed by contiguity. All recall is by association. Therefore, all recall is by contiguity. Naturally, in the course of a lifetime, any one idea has been associated with many others. The problem of recall is the explanation, not of how and why ideas have become connected, but of why a certain idea calls up one associate at one time and a very different one at some other time. Certainly one reason is to be found in the circumstances attending the formation of the association and another is to be found in the present contents of consciousness. Expressed in nervous terms the problem can be stated thus: Since the nerve-current takes the path of least resistance, why is it that the pathways leading from a given region show different amounts of resistance at different times so that the direction of nervous drainage is variable instead of constant?

Turning first to the residual effects of the learning itself, we may recall that the strongest associative connection was formed when the regions involved were most intensely active. When, under the conditions favoring the

formation of associations, *M* and *N* have been violently active together, and when *M* and *O* have been moderately active together at some other time, less resistance remains in the *M* to *N* pathway. This route will consequently be favored for use when *M* is subsequently restimulated. The favoring condition is known under the name of *intensity*. Since the external condition most favorable to great brain activity is intensity of stimulation, it follows that intense experiences are more likely to become associated than milder ones. The fundamental principle is that an intensive current will produce greater decrease in resistance than a weaker one when both operate for the same length of time.

A similar effect can be produced by a different means. Frequently repeated weak currents can accomplish in time as much decrease in resistance as one passage of a stronger current. Consequently, *frequency* of use of the association pathway is a condition favorable to the formation of a strong association which may result in recall. Further repetition may make the pathway more pervious than the one formed by intensive currents.

On the other hand, we have seen that with disuse the resistance of the synapses increases. This means that if the association pathways are not employed from time to time, recall is interfered with and forgetting ensues. Re-use again decreases resistance temporarily at least. Consequently, *recent* passage of a nerve-current over an association pathway may result in a relative change in the balance of resistances, so that this pathway becomes the effective one. Consequently, the effects of *recency* may be to change the relative resistance in the pathways sufficiently to divert the nerve-current and affect recall.

Sharply contrasted with recency, in expression at least, is another principle, known as *primacy*. If N is the first idea to have been associated with M, it has an enduring advantage in recall over other ideas which subsequently have been associated with M. Just what the explanation must be is not very clear. It is possible, though, since MN is an association already formed when other associations, MO, MP, etc., are in process of formation, that the pathway MN, being already formed, will divert some of the nerve-current from the MO pathway. The result is twofold. First, an increase in the strength of the MN pathway because of the additional energy recently sent over it; secondly, a decrease in the possible strength of the MO pathway because of the energy diverted from it. At any rate, the fact is unquestioned. Primacy is a factor in recall as is shown not only by common observation, but also by our tendency, as we grow older, to go back to our first associations formed in childhood.

Analysis shows, then, the existence of four different conditions attaching to learning, which account in part at least for the variability of recall. These are known under the names of intensity, recency, frequency, and primacy. But these principles are strictly mechanical, depending upon the chance of external contiguity, succession, intensity, and the like. If they were the only factors influencing recall our minds would veritably be adrift upon an ocean of circumstance.

Fortunately the human being may be internally controlled as well as impelled by external forces. It behooves us in this connection to determine how mind can steer itself; or, in other words, how consciousness itself can determine and control the course of recall. Obviously, it can-

not do this in any complete way, for recall depends upon the associations already formed, and the associations already formed depend upon the accidents of spatial and temporal relationships. But we can put ourselves into situations favoring the formation of associations which are desirable to ourselves. We can go to college, take a trip abroad, subscribe to the *Wall Street Journal* if we think the data encountered will be of service to us. We can control our environment to this extent at least and be in a mentally receptive attitude which favors the formation of associations. But even with our present equipment of associations, we can render the recall of certain ones more likely to occur. This is a result of using what has already been called the present contents of consciousness.

For this rather general term we may, if we wish, substitute more concrete ones. Desire, intention, purpose, describe the condition in whatever terms we will, the fundamental nervous principle is the same in all cases. The awareness of a particular thing, be it object or memory, depends upon the activity of a correlated brain region. This activity not only presses onward through associated regions, but it also decreases resistance in pathways leading toward itself, a condition which facilitates the drainage of nerve energy toward itself. And the incoming energy, as it flows over previously modified regions, results in the recall of ideas previously associated with the idea in mind. The effect might be likened to an attraction exerted on other associated regions, focalizing their direction of drainage and clustering about the original idea a host of associates from which selection can be made. When we see the numbers $\frac{6}{4}$, the idea of adding will evoke the further idea

10, subtracting will call out the idea 2, multiplying 24, and so it goes. The idea in mind, the purpose, the intention, call it what we will, can determine what associated ideas shall be called up and in that way determine what shall be recalled.

So far we have been dealing with what we may term the chain association, the recall of events in the order in which they have been experienced, the use of series of associations by contiguity. When two or more elements are thus associated by contiguity, the result is what we know as memory, and the series of events recalled may be referred to as a system of memories. Obviously, as long as we stick to one system of memories, we can do nothing but live over the events of the past in the order in which they occurred. Were this the only possible type of association, life would be a humdrum, unprogressive affair. Invention would be impossible, whatever was new would have to wait upon the accident of discovery.

Two different systems of memories, however, may have at least one term in common. For instance, if one system of memories be composed of the elements *A*, *B*, *C*, *D*, *E*, *F*, *G*, and the other of *H*, *I*, *B*, *J*, *K*, *L*, *M*, a connection between the two systems by way of the common element *B* permits the recall beginning in one system to switch to the other by way of *B*.

A similar, though somewhat more complex, condition appears when one element of one system has been, in some other connection, associated with an element in the other system. For instance, if *D* and *K* have been associated at some time in the past, a link between the two systems is found. The advantage of this sort of nervous connection

is that it permits the bringing together mentally of images which have never been experienced together as a result of juxtapositions of physical objects. We can, then, bring together in consciousness ideas of objects which have never been, as far as our experience goes, related either spatially or temporally. The resulting ability to transcend and to surpass the physical universe is a great aid in progress and advancement. It is the basis of all invention, whether great or small. It is the key-note of constructive imagination and without it reasoning would be impossible.

This complex form of association, which in its simplest form is two associations by contiguity which have a common element, has been known as *association by identity* and also as *divergent association.* When we consider the almost incredible number of systems of memory possessed by the average human being, the number of cross connections between different systems is correspondingly great. A mechanism is thereby provided for rearranging and recombining past experiences in a most complex way. What the actual achievement shall be is of course determined by the relative resistance offered by the divergent neural pathways in each case. The resistance, as we have seen, is determined by primacy, recency, frequency, and intensity on the one hand, and on the other by the idea in mind, the purpose, the attitude, and the intention.

Two special cases of association by identity which have attracted much psychological and economic attention are known as *association by similarity* and *association by contrast.* In association by identity the tendency is to proceed by wholes, by definite concrete objects. For instance, the L. C. Smith typewriter suggests Syracuse; Syracuse sug-

gests salt; salt suggests Lot's wife; and Lot's wife suggests the Bible. In similarity, parts of ideas, some specific attribute or quality is emphasized at the expense of others. If we consider the yellowness of the moon, for instance, the color may call up any other object of the same hue with the result that we get a connection of a mental sort between moon and cheese or moon and butter which probably never would have resulted from simple contiguity. It is evident that similarity like identity is the result of two associations by contiguity which have a common element. The common element neurologically involves a cortical region connected with two others by divergent association.

Association by contrast is very similar in principle to similarity, for it is impossible to contrast two things which have nothing in common. Two colors can be contrasted because they have the common element, two tastes can be contrasted for they are both tastes, but a taste and a color cannot be contrasted, for they have nothing in common. The common element here, as in similarity and as in identity, serves as the connecting link. Efforts have been made to reduce contrast to contiguity, for it clearly is possible that contrasting colors, as red and green, and contrasting tastes, as sweet and sour, have been experienced simultaneously. But whether this simple explanation will satisfy some of our more sophisticated contrasts, as finite and infinite, or whether such differences are the result of a merely verbal negation, is at present an unanswered question.

Summary: In the association process we have found a binding-together mechanism which permits the assemblage of qualities into the awareness of the object. For the ob-

ject possesses fundamentally and perpetually the same qualities, or it is not the same object. Because these qualities are experienced together, they become associated; when they become associated one calls up the other. When they are continually together, frequency of stimulation welds them into an associative complex of very great durability and intimacy of connection, so that the arousal of any one conscious element means the arousal of all. The awareness of the object is the result. A further and higher association between objects then follows in accordance with the same general plan of neural functioning. The result is a system of memories. But cross connections between systems make it possible for experience to get outside of and ahead of itself, thus providing for imagination, reasoning, invention, originality in all forms.

We discovered, also, the existence of a second conscious element, correlative with the sensation, a ghost of the sensation which is called the image. The image represents material on hand, accessible for instant use. These images, as assembled by association, develop into systems of memories.

Certain fortuitous circumstances introduce order and arrangement into our memories which makes them more useful than mere assemblages of ideas. For it happens frequently that attention is directed successively to different aspects of the same object. For example, I notice a tree. The detection of a peculiarity of the bark is followed by the observation of the shape of the leaf; this, in turn, is succeeded by the idea of the angle of branching, etc., so that these characteristics of the tree, because attended to successively, are connected to form one system.

As a result we find that our memories of objects and situations tend to become organized in terms of succession. When we observe another tree, a similar system of associations may be formed, or, following the laws of recall, the leaf of the second tree may be compared with the leaf of the first, and similarities or differences noticed. When this is done frequently, the result is a system of knowledge about leaves of trees, their barks, or any other series of observed peculiarities.

Whatever has been known may subsequently be recalled, thus becoming the idea in mind or present contents of consciousness. This, in turn, may attract to itself other impressions that seem to fit into the system. The result is more or less independent systems of organized memories which have been known under the terms apperceptive masses and interests.

Since the observed qualities and objects are the expression of order in the universe, since their relations in space and time are equally of an orderly nature, the resulting associated experiences, as they are originally formed, tend to show the same types of order and arrangment. Only as various memory systems cut across each other is this order disturbed, as occurs in certain forms of insanity and in some of the scenes depicted by imaginative writers. Then originality appears.

PROBLEMS

1. Is retention physical, physiological, or psychological?
2. How is consciousness organized?
3. Draw a diagram which will show by width of line the formation of association pathways.

4. What are the two fundamental considerations involved in the formation of associations?
5. Which is more effective in recall, intensity or frequency? primacy or recency?
6. Why are more than the mechanical rules of primacy, recency, frequency, and intensity necessary?
7. Bring out the relation between association by similarity and association by identity.
8. In what sense is association by similarity focalized recall?
9. Find out the steps involved in some invention. Upon what forms of association do they depend?

CHAPTER VI

MEMORY

MEMORY, or the recall and recognition of experiences which have become associated because of spatial contiguity or temporal succession, has been studied in very great detail. The special laws discovered have a definite bearing upon the formation and use of associations. Not only does this fact make it desirable to study memory while the principles of association are fresh in our minds, but also an understanding of memory is essential for the development of the following topics of attention and perception.

Analysis shows that memory is a complex process, consisting of four parts. The first, known under the various names of impression, learning, memorizing, is the result of any situation favorable to the formation of associations, the temporarily overlapping and strong activity of any two brain regions. The second part is retention, the keeping of the nervous modifications which result from the passage of the nerve-current through the region. The third is recall, the conscious result of restimulating the modified areas. The fourth part, recognition, is the result of the arousal of other associations, frequently of the time and place of the experience recalled. Locating the event in our own past experience gives the memory-image a guarantee of reality which may be entirely lacking from a purely imaginary construction.

When we come to consider the results of experimental

investigations upon memory, we find that the word is used in three very distinct senses. In the most limited sense, memory is used to describe the condition in which complete recall of materials learned is possible. This is the situation when a declamation or a piece is "learned by heart" so that it can be repeated word for word. This variety may be termed *recall-memory*.

The second form is *recognition-memory*. Here complete recall is usually impossible, but when the original situation is re-experienced, we recognize it as something we have experienced before. This form of memory is a result of incomplete learning. The association pathways are not sufficiently well formed to be the natural channels of neural drainage. But when the cortical cells are restimulated, their attraction effect is sufficient to lead to complete recall of the intimately associated ideas.

The third type of memory may be called *association-memory*. In the extreme form of this sort, the associative pathways were so poorly established or possibly endured so short a time that neither recognition-memory nor recall-memory is possible. But that some associative tendency is left is demonstrated by the fact that a relearning of the same material at a subsequent time does not take as long as did the original learning. There is a saving both of time and of the number of repetitions in relearning. These three forms of memory are consequently to be distinguished by the amount of associative strength developed in the original learning. When it is slight, association-memory is the result; when it is somewhat greater, recognition-memory appears; when the strength is very great, complete recall is possible.

It can readily be seen from the discussions of association and memory that learning involves physical work. For learning reduces to overcoming resistance in the synapses and making modifications in the physical nervous structures. That recall is a conscious phenomenon does not change the situation in any way. Learning, memorizing is creating changes in physical structure and is consequently physical work. It is well to bear this fact in mind when we consider the laws of learning.

One of the very fundamental laws of learning states that *the amount learned varies almost directly with the number of repetitions*. Obviously, this law could not have been determined if the materials used were in part familiar and in part unfamiliar. This would be the condition if words, geometrical figures, pictures, poems, bits of prose, and like materials were used. To avoid this difficulty, it is customary in much of the work upon memory to use *nonsense syllables*. A nonsense syllable is composed of two consonants separated by a vowel, provided that such a combination of letters does not make sense in any language known to the subject or learner. For instance, if we start with the first consonant in the alphabet, b, repeat it a second time, b–b, then try out between the two b's the five vowels in order, bab, beb, bib, bob, bub, we find that only the second one, beb, is apparently without sense, and so makes a proper nonsense syllable. By this method it is possible to get several thousand nonsense syllables, which is sufficient material for most memory experiments. This was the type of material used to prove that the amount learned varied almost directly with the number of repetitions. The result is what we should expect from what we know of

the association process. For we must believe that equal intensity of activity of two cortical regions upon two separate occasions shall have equal associative results. In the long run, one repetition must be about equal to any other in the amount of cortical action produced, or, at any rate, in the amount of associative tendency established.

A corollary of the first law, and having the same explanation, is that *the amount learned varies with the vividness or intensity of the impression.* This follows directly from the consideration of the principles favorable to the formation of associations.

Modification of experimental procedure gives results indicating the formation of associations not only between contiguous elements of the material to be learned, but also between syllables separated by one or more syllables; for example, the first and third, first and fourth, first and fifth syllables. The strength of the association between alternate syllables is, however, considerably less than that between contiguous syllables. Associations of decreasing strength are found to exist between the first and fourth, first and fifth, first and sixth, and first and seventh. Over gaps in the material larger than this, that is six elements, little if any associative strength is discovered. *The existence of associative tendencies between non-contiguous members of a series has been called remote association.*

The explanation is quite simple. Assume three brain regions, *A*, *B*, and *C*. When *A* and *B* are stimulated in immediate succession an exchange of energy between them takes place. When *C* is stimulated in turn it attracts from both *A* and *B*, and both *A* and *B* discharge into *C*. But *A* is now less active than *B* and consequently it sends less

energy to C than does B. A connection is formed between A and C, though it is weaker than the connection between either A and B or B and C. Extension of the same explanation to include seven brain regions will account in a satisfactory way for remote associations.

Materials read rhythmically are more easily learned than those read non-rhythmically. The rhythmic form combines the words or syllables into groups with the result that the unit becomes more inclusive. The units tend either to disappear as a whole or to be recalled as a whole with the chances somewhat in favor of the latter. The structure of the rhythmic unit itself seems to favor the closer associative connection between members of the same unit than between contiguous members of different units. For in rhythm both accent and time changes are introduced. Accent is either increased intensity or duration of the sound, and both account for intensive action in the brain region involved. This, in turn, favors association. Also the members of the rhythmic unit occur closer together in time than do the contiguous elements of the different rhythmic units. And the shortness of the time interval again favors association.

Material to be learned should be read through as a whole and then reread as a whole rather than be split up into small units each of which is learned completely before another is attempted. When the part method is used, needless associations are formed between the beginning and end of the section which not only waste time but are also likely to disturb recall. The part method of learning is most disadvantageous when the parts are smallest. A selection which takes over fifty minutes to read through once is better

divided into smaller portions which take about twenty minutes to read.

The "whole" method is made even more effective when combined with the prompting method. In this, the learner reads the selection through from beginning to end a few times and then endeavors to repeat it. When he fails he is prompted and then goes on until he fails again, when he is prompted once more. The active effort by the learner to reproduce the material greatly facilitates the learning process.

The precise explanation is a matter of conjecture. It may be, of course, that attention is more concentrated, a condition which we shall see corresponds neurologically to great activity of the brain regions used in forming the associations. Possibly it is because the desire to learn, which is in part responsible for the success of this method, is the reflection of a nervous condition which exerts an attraction upon the regions active in learning, thus compelling a more complete focussing of nervous action and an inhibition of any tendencies toward spreading of the nervous action which would go to the formation of extraneous and unnecessary associative tendencies. Perhaps it is because the issuing of the mental content into overt response—and the action of the motor regions of the brain may be considered as having an attractive effect equal at least to the sensory areas — further tends to focalize the nervous drainage. At any rate, whatever be the explanation the method is extremely effective.

The opinion that focalizing of nervous energy into a limited number of channels is a condition favorable for rapid learning is reinforced by other experimental evidence.

For it has been found that in "learning by heart" the rate of reading should be as rapid as possible, for this tends to prevent the formation of associations between the material read and our store of memories. On the other hand, when we are learning "ideas," as in going over a class assignment, a slower rate of reading which permits the formation of associations between the material studied and our equipment of ideas is a more advantageous procedure.

In many ways the most important principle of learning is the *law of divided repetitions: successive repetitions of the material to be learned should be separated by at least ten minutes, though an interval of several hours is even better*. The same phenomenon, considered from a somewhat different angle, goes under the name of *retroactive inhibition*. This law states that *a learning period should be followed by a period of physical and mental quiet*, which apparently gives the impression a chance to "soak in" or "set." It must be understood that these two terms, soak in and set, are used in a figurative sense; nothing like the setting of concrete occurs.

The more orthodox explanation is found in an appeal to the physical principle of inertia, which in this physiological manifestation is known as the *perseveration tendency*. The nerve action does not cease when the stimulus is removed, but continues to "persevere" for some little time afterward. The unearned increment of nervous action which flows over the connecting pathways produces a still further decrease in resistance of synapses and so facilitates the learning. This is the condition existing when a rest period follows learning. On the other hand, when we turn from one task to another, the picture is quite different. The

learning involves one complex group of cortical regions, which are becoming intimately connected one with another. As long as this continues, the two forces of radiation and attraction produce a constant interchange of energy between the active regions. But if, immediately afterward, a second complex group of cortical cells becomes active, they attract from the first group much, if not all, of its nervous energy, and there is nothing left to produce further modifications of resistance between the elements of the first group. The establishment of associations between the different elements of the first group of cells is consequently interfered with and the effects upon recall are disadvantageous.

This type of explanation is made to seem even more plausible when we take into account two other features of retroactive inhibition. When the time interval separating learning and working on some other task is shortest, the effect upon recall is greatest. When the time interval is lengthened, the effect upon recall becomes continuously less and less. In the first case, perseveration has no chance to work; nervous drainage is immediate. As the time interval increases, perseveration works for longer and longer times and shows its effect in the amount recalled. In the second place, the greater the similarity of the materials used in learning and in subsequent work, the greater the effect upon subsequent recall; dissimilarity of materials is followed by less effect upon recall. It is but plausible to believe that similar materials or similar tasks involve more closely allied cortical regions than do dissimilar tasks. And there would naturally be greater drainage between the more closely associated regions used in similar tasks than between regions having fewer connections.

In an indirect way it is possible to cast further light upon the problems of learning by studying the phenomena of forgetting. The first to engage our attention is the law of

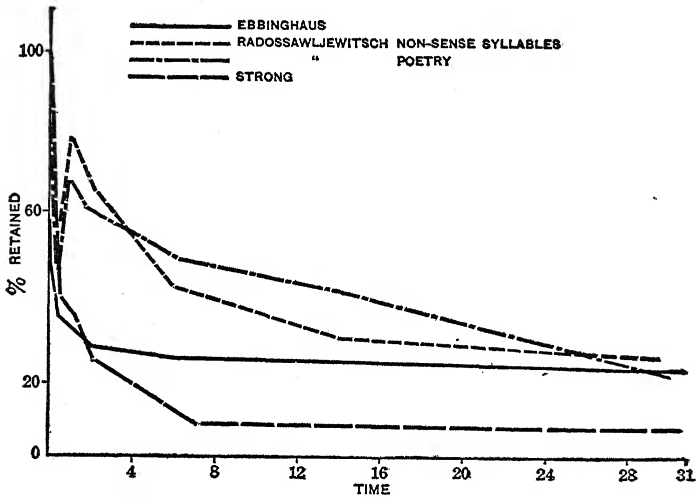


FIG. 26. These curves show the result of four experiments on the rate of forgetting. The amount retained is given in percentages on the perpendicular line, the elapsed time on the horizontal.

the rate of forgetting. Obviously, this depends in part upon the thoroughness of the learning and in part at least upon the kind of material learned and in part upon whether the measure of retention be recall, recognition, or associative memory. It is highly probable, also, that individual differences play a rôle of considerable importance. The results of four investigations are thrown into graph form (see Fig. 26). In spite of minor discrepancies, they agree very well in the main essentials. From them we can infer

that *the rate of forgetting is very rapid at first and then gradually becomes slower and slower, until finally a condition is reached in which there is no further forgetting*, of an associative sort at least.

A very important principle of forgetting goes under the name of *associative inhibition.* This situation results from a multiplicity of associations. In its usual form it slows up thinking, or at least the reaching of conclusions. It explains why, with increasing age and wisdom it takes us longer to reach decisions than it did in our more haphazard and ignorant youth. We simply have more ideas to take into account. In its more extreme form the result is known as stage-fright and getting rattled. *If at different times in the past we have formed associations, a–b, a–c, a–d, a–e, etc., when a is restimulated it sometimes happens that none of the pathways connecting a with b or c or d or e has any advantage over the others by way of greater permeability.* The result is either a mental vacuum, a situation most distressing in itself, or an equal arousal of all the ideas simultaneously, making it impossible to single out any one for emphasis. It is odd that too many associations should produce much the same effect as too few. The remedy is to do anything, say anything, keep command of the situation until the blocking disappears. Then one regains control of his knowledge and resumes his normal course.

The last law of forgetting which we wish to discuss is known as *generative inhibition. If we try to form the two associations, a–b and a–c, at the same time it takes longer than it does to form both separately*, and recall is less perfect. The situation here is very similar to that encountered in retroactive inhibition. When three brain regions are

active in rapid succession, there ensues a waste of energy which might otherwise be used in forming associations. In the case cited above where A is to be associated with both B and C, the waste occurs because of the tendency for B and C to become associated. Even when longer intervals separate the formation of the A–B and the A–C associations, the formation of an association tendency between B and C is not unlikely. For when A is stimulated, B tends to become aroused, and when C follows as a stimulus the overlapping period of activity of B and C is sufficient to cause an associative tendency.

The foregoing laws of learning and forgetting have accumulated gradually as a result of many years of patient research. In a general way, with the one exception already noted concerning the rate of reading, they hold for both *rote* and *logical* learning.

However, significant differences between these two methods of acquiring information are to be noted. In rote learning we form a definite mental habit, in that each idea is determined by its predecessor, and we seek through repetition to make the order of succession exact. In logical learning the exact form of the image is ordinarily unimportant, but its meaning is everything. Meaning is essentially a substitution of equivalents. Such substitution obviously could not occur unless there were an equivalent to the new impression. The result is that the meaning of the new impression is called into life through the cortical arousal of its equivalent, and the two experiences tend to become connected.

Furthermore, in rote learning the sequence of events is imposed by external conditions with the result that the as-

sociations formed must all be new ones. In this situation little is to be gained from the idea in mind, plan, purpose, or other subjective condition. In logical learning, on the other hand, entering impressions must be combined not only with each other but with our previous experiences. Now as soon as a past experience is rearoused, its nervous correlate because of its attractive effect definitely aids in the formation of the association. Not only so, but because of the whole trend of physiological action the new idea also becomes associated with many of those which had been connected with its older equivalent. The entering idea therefore becomes part of a system occupying a place in relation to the other parts, which in a way had already been prepared for it. Even when no ready-made niche exists for it a little thought will ordinarily provide one.

Consequently, logical learning is not only easier, but is also more permanent than rote learning. All first learning must be rote learning, but before very long we find our knowledge, even of new subjects, taking on a systematic form which enables us to relate to it other bits of information as they appear. This advantageous aspect of logical learning is at the basis of what is probably the oldest and soundest pedigogical principle in existence: "Always explain the new in terms of the old."

It is time now to turn our attention to other phases of memory. Retention can be dismissed with a word, for it has been sufficiently covered in the preceding chapter on association.

Recall, on the contrary, brings up several questions. Among the more important of these is the relation between the sensation and the recalled *image*. We found eight

classes of sensations — visual, auditory, cutaneous, gustatory, olfactory, kinæsthetic, organic, and static. How many of these different classes of experience can be recalled in the form of images? There is no question about the visual, auditory, cutaneous, gustatory, and olfactory. Some writers admit the existence of kinæsthetic images, others deny them on the ground that the situation which would call them out would also produce muscular contraction, and that what we consequently experience is not an image but a weak kinæsthetic sensation. Concerning the organic images, there is some dispute, but it seems probable that the clearer-cut organic sensations may be revived as images. Likewise, if the static sense contributes any specific sensations, they probably may be revived in the form of images. In general, we may say that there seems to be no good reason why any of the sensations may not be reproduced in the form of an image. Conditions similar to those which produce a visual image ought to bring about a kinæsthetic image as well. We conclude, then, that all eight types of images are possible.

That some are used more freely, easily, and generally there can be no doubt. Most persons tend most frequently to think of things not present to the senses in terms of sight, hearing, and movement. When these are not adequate, other forms are brought in, but this happens with relative infrequency. Some persons are mainly visual and auditory in their types of imagery, others visual and kinæsthetic, and still others auditory and kinæsthetic. It seems probable that visual imagery is the most common form.

The problem of types of imagery was first raised by

Francis Galton, an English scientist. As a result of the evidence obtained from a questionnaire circulated among the Who's Who of Great Britain, he reached the conclusion that the artists and literary folk tended to have visual imagery predominantly and the scientists auditory. While subsequent researches have not wholly confirmed this conclusion, they do suggest that artists, writers, and those who are continually dealing with concrete particular objects and events tend to use concrete, particular images which are *copies* of the previous experiences. Such copy images may be visual, auditory, kinæsthetic, or any other sort. On the other hand, those who deal with abstractions — philosophers, scientists, and mathematicians — tend to use *symbolic* images. That is, images which do not resemble the object, but which through association mean the object. The symbolic images of most frequent occurrence are word images and they, in turn, may be visual, auditory, or kinæsthetic in form.

If the image is a copy or reproduction of the sensation, how do we distinguish between them? Under normal conditions we seldom if ever make mistakes, though when the characteristics of the object are controlled in the laboratory errors not infrequently occur.

The most obvious difference is one of intensity, for the image is seldom if ever as intense as the sensation. When the sensation is much reduced in intensity, it is sometimes confused with the image.

The image furthermore discloses a certain transparency. When we project it against a wall, we can still see the wall through the image. From this standpoint the image is somewhat like a *ghost* of a sensation.

The sensation, because of its immediate physical origin, tends to be more permanent, more stable than the image, showing less fluctuation and wavering. Sensations, also, are much richer in qualities than images. For instance, it is estimated that we can discriminate some 35,000 visual qualities, whereas few persons can call up even 100 different qualities by means of corresponding visual images.

Possibly the most important difference, because of its implications, is the greater control we have over the image. The sensation, because its nature is so rigidly imposed by the external conditions, suffers from the same limitations as does the object. The object, as we have already seen, is limited in space and time. It can move just so fast, grow or decay only so rapidly, weigh so much, or fall so quickly. And the sensations and perceptions must keep pace with the physical changes. On the other hand, the image is spaceless, existing only in time. Even if it exists *now* it can mean any time. The image, consequently, is practically free in space and time, thus giving its possessor a great range of control over it. For example, if you will form a visual image of a tree, you can turn the image upside down instantly, you can move it about town at will, you can, in imagination, make it grow out of somebody's head or put it on top of a church steeple; you can put Julius Cæsar under it writing his "commentaries"; you can put it in any place at any time; you can control it in a very thoroughgoing way.

Recognition, the fourth part of the memory process and the only new element introduced, consists essentially in locating the recalled events in one's own past experience. It would be well to point out in this place that there are

two kinds of experience, the direct and the indirect. The direct are those occurrences of which we have first-hand information, and the indirect correspond to hearsay, testimony in courts, and the kind of data which we receive from books, periodicals, newspapers, plays, travelogues, other persons, etc.

In recognition, it would follow naturally that associations calling up the time and place of the original experience would be the most satisfactory means of identification. For if we can tell accurately when and where the events occurred and give all the necessary settings there is no doubt whatever that the recurring idea is a true memory image and not some figment of the imagination.

It happens frequently that the same event has been experienced at a number of different times and at a number of different places. And because of the blocking, or associative inhibition, which prevents these numerous associations from arising, it is necessary that some other means of identification be used.

This is found in the motor associations or habits which we have developed with respect to a given situation or object. For instance, a man recognizes his own hat by the way it feels and the way it fits, he recognizes his own fountain-pen because of the way it works when he tries to write with it. So any of these different kinds of data may be sufficient in itself to constitute recognition.

In any case recognition is an association process and the associations most frequently called out are time, place, and movement.

A question of considerable practical as well as theoretical importance is whether memory can be trained. Ex-

perimental results clearly indicate that any one kind of memory, as visual memory for poetry, can be trained to a certain extent. But a point is reached sooner or later beyond which further practice has no effect. Which part of memory — learning, retention, recall, or recognition — is trained? Recognition, we saw, depends upon time, place, and use associations, that is, upon purely physical connections in the brain. The only time at which these can be more thoroughly and completely formed is during *learning*. Similarly, recall is the result of the re-use of previously formed modifications which again are the results of *learning*. And so also the modifications retained are the outcome of the nerve energy flowing over them during the process of *learning*. Any improvement in memory, therefore, is the result of improvement in learning. Greater efficiency in rote learning can be brought about only by making one unit of nerve energy produce maximum results by way of modification. This can be accomplished by following the rules of learning already given. Improvement in logical learning follows with increased knowledge which provides greater possibility for associative connection, and also from the voluntary effort to find a suitable place for the new impression inside the already existing systems.

Every one must have noticed the advertisements of memory-training systems and been impressed with the wonderful feats of their authors. The important question in this connection is: How many things should we try to remember? Certainly no more than we have occasion to use from time to time, for other things are promptly forgotten. Economy of time certainly is better obtained by keeping

memoranda than by memorizing an equally large list of facts.

Some of the memory systems are parodies on logical learning. When the mnemonic method is employed some standard form, either a list of key-words or a similar group of key-numbers, must be learned by heart, and the new material in some way be connected with these keys. Since the lists of key-words are copyrighted it is impossible to reproduce them here, but the key-numbers or alphabetical numbers, as they are frequently called, have been given in so many places that certain adaptations may be offered. For instance, if it is necessary to remember numbers no matter whether they be addresses, telephone numbers, prices, ages, or what-not, it is sometimes found to be of assistance to take a word or words containing ten different letters, write them on paper, and put the digits underneath the letters. As for example:

B	L	A	C	K	S	M	I	T	H
1	2	3	4	5	6	7	8	9	0

If the price of $12.49 is to be learned, write down the letters occupying the same column as 1, 2, 4, 9, obtaining B, L, C, T. Introduce in between or at either end of these consonants any group of letters which are not found in the word *blacksmith*. Since words are, in general, more easy to recall than numbers, we have, by employing this method, made the learning process at least less difficult. Another word which is frequently used is *clean-shirt*.

Sometimes instead of using arbitrary words of this kind teachers of such systems recommend the use of consonants

which are supposed to resemble the numbers either in shape or in sound as shown in the following examples:

1	2	3	4	5	6	7	8	9	0
t	n	m	r	l	sh	g	f	b	s
d					j	k	v	p	c
					ch				z
					g	qu			

At first it will be quite difficult to discover the words which will fit the necessary numbers, but we are assured that a slight amount of practice soon makes this task easy. A person well known to the author has remembered for a number of years a friend's telephone number by the words *white comb*. The single letters T, C, M, B correspond to the numbers 1039.

Modifications of this system can be applied by taking the first letter of each of the words to be remembered, then find familiar words which begin with the same letters and, if possible, of such a sort that they make a jingle. Many of our bits of popular lore have been put into such form. What student of music has not learned "Every good boy does finely" to enable him to recall the notes appearing on the lines of the musical staff, and "Face" for those appearing between the lines? Similarly, the lengths of months can be remembered by:

"Thirty days hath September,
April, June, and November."

And the nautical lore contained in the statement:

"Red in the morning, sailors take warning;
Red at night, sailor's delight."

Or,

> "Evening red, morning gray
> Sends the traveller on his way."

Another artificial device is the association method whereby the learner connects by more or less artificial words or ideas the end terms which are to be linked together.

These are samples of some of the numerous memory systems which have been developed and put upon the market.

Before leaving the subject of memory training certain points should be made clear. *There are many different kinds of memory, and only one can be improved at a time.* This one kind of memory is capable of being improved only to a certain extent. A facility is soon reached beyond which there is no further improvement. Memory systems are at best makeshifts, and while it is ordinarily an easy matter to select one method which will work in any given situation or for one kind of material, it is much more difficult to obtain one which has any universal application.

Memory systems, no matter what kind is used, demand so much ingenuity on the part of the individual and so much time in learning the necessary keys that, unless he has actually to keep in mind a great mass of similar material, little if any time is saved by using them. Recognition fades or disappears entirely when such memory systems are employed. In fact the only improvement which can be made in memory is in the learning process, by means of better observation, repetition, and vivifying of the things to be remembered. Memory systems are not

electrical attachments which can be fitted to the outside of one's head, thereby making learning easy. They are simply devices which put a sugar coating on the pill of hard work. *For a good memory is a result only of native endowment and good, consistent, and arduous effort.*

Summary: From the preceding discussion it appears that memory is a process which adds greatly to our fund of information, thereby increasing our practical value. An observation once made may become a part of our permanent equipment. It may be used as many times as necessary, and each time it is thus used it becomes more indelibly a part of the self.

As we have seen, learning may be done in either of two ways, by rote or logically. In the former case, it takes the form of making associations by contiguity, the linking together of events attended to in immediate succession. In this situation the sequence of events and their appearance of order is imposed upon us by external forces, consequently the factors governing the formation of the associations are objective.

With logical learning, the situation much more closely resembles that encountered in similarity and contrast. Events tend to become related mentally into systems. These things, which have been known, may function anew as subjective conditions, attracting to themselves whatever seems to fit into the system. This is essentially what happens in logical learning and is at least one of the reasons why logical learning is easier than rote.

Furthermore, we found that the memory image is a ghostlike reincarnation of the original experience. It may take any of the forms the sensation or percept assumes and,

because of its freedom in space and time, it has many advantages when used in thinking.

PROBLEMS

1. Why is recognition necessary for memory? What would you call memory minus recognition?
2. In what sense is memorizing doing physical work?
3. Under what conditions does one unit of work in memorizing produce maximum results?
4. How many kinds of memory are there?
5. To what extent can memory be improved?
6. How is the "will to learn" effective?
7. Explain in terms of the theory of association outlined in the previous chapter the following:
   (*a*) Remote associations.
   (*b*) Rhythm as an aid to learning.
   (*c*) The advantages of the "whole" method.
   (*d*) The effect of the rate of reading.
   (*e*) The efficiency of "divided" repetitions.
8. What are the advantages of forgetting?
9. What are the advantages of remembering?
10. What are the disadvantages of remembering?
11. How do we distinguish between sensation and image?

CHAPTER VII

ATTENTION

The predominance of some experiences over others has already been mentioned under the term *attention*. Attention was found, in the previous pages, to be primarily the result of intensive stimulations which chanced to impinge upon the sense-organs, and the intensive stimulation, arriving at the brain, creates a greater cortical commotion than other incoming currents. The outcome of all the stimulations affecting a person at any given time is a series of experiences of different intensities simultaneously present in consciousness. Their relative conspicuousness is originally determined by external chance.

But we have furthermore found that experiences can be resurrected as memory images. There is no reason why a number of memory images may not also be simultaneously present in consciousness, and they may also differ in conspicuousness or intensity.

We may then attend either to a memory image or to an external object. Equally well, we may attend simultaneously to an object and an identical or similar memory image, or to two or more similar or identical memory images. When this occurs, there ensues an overlapping or superposition of the intensive elements common to the two experiences and a diffusion of the intensities of the dissimilar elements not unlike the umbra and penumbra of a shadow. The diffusion produces no increase of intensity of any one

element, whereas the overlapping does. This condition produced by the "super-position" of intensities of the similar elements is known as *clearness*.

Intensity and clearness are by no means the same. Intensity means sheer amount of energy, clearness means outstandingness of certain elements through emphasis of certain details and subordination of others. The spontaneous yelling at a football game is intensive enough, but it assumes clearness only as it becomes concerted through the efforts of the cheer leaders. Clearness then is the result of the co-operation of two or more intensities, be they great or small.

Some four or five different degrees of clearness are to be found in a cross-section of consciousness. They are usually represented by a series of concentric circles, as in Figure 27, arranged to resemble a target. The bull's-eye is the mental process attended to — *the focus of consciousness.*

The next ring includes those ideas which have already been in the focus and have been displaced and those which in the next few moments will occupy the focus, supplanting the idea now there. The third ring may be pictured as including those mental processes which serve as distractors, such as noises, odors, movements of others, and prominent cutaneous, organic, and kinæsthetic sensations. The fourth circle hems in those bits of consciousness which are a constant accompaniment and a relatively stable background against which the more variable experiences are projected. It consists mainly of the sensations coming from muscles and internal structures.

Outside of this last circle is the entire field of the uncon-

scious. For purposes of classification, this may be divided into two parts. The first consists of the many things which we have never experienced and consequently never have

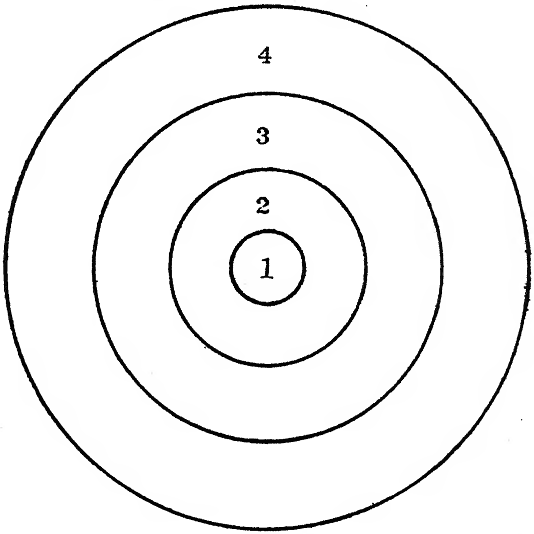


FIG. 27. Showing the field of consciousness. 1 is the focus of consciousness or attention. 2 shows the second ring, including those ideas which have just been in the focus and those which are just about to go into the focus. 3 contains the visual, auditory, olfactory sensations, etc., of which we are conscious, but to which we are not attending. 4 contains mainly the organic sensations which form a more or less constant background of consciousness.

known. The second is composed of those experiences which we have at some time had but which have lapsed from consciousness. We may picture it as the nervous modifications made in learning. This, sometimes called *the subconscious,* is really unconscious, physiological, and the basis of memory.

If a second "cross-section" of consciousness be taken separated from the first by an interval of a few seconds, certain changes in the pattern will be noticed.

The mental process which was in the focus is no longer there. It is now in the second ring, having taken the place of some other idea. An idea which probably was in the second ring is now in the focus. The contents of the third and fourth circles will show less change.

In studying the longitudinal section of consciousness, the mental processes appear to have a progressive wave-like motion. As one idea is supplanted by another, the first appears to move onward, making place for its successor and simultaneously undergoing a change in distinctness. Such change corresponds to *fluctuation* of *attention*, *i. e.*, the substitution of one focal idea for another.

Experiments have demonstrated that it is possible to attend to an idea for only about four seconds. It is then superseded by another. This period represents approximately the maximum time; the usual period of an attention process is much less, ordinarily not over one second.

Several causes have been suggested to explain fluctuation of attention. Fatigue of a sense-organ would produce a fluctuation of attention, for the structure is incapable of sending the maximum nerve-current to the brain for more than a very few seconds at a time. Fatigue of the brain would produce a similar result, for fatigue not only decreases the efficiency of the part of the organism involved, but also increases the resistance of synapses. There occur regular, rhythmic alterations of blood-pressure, known from their discoverers as *Traube-Hering* waves, whose periodicity is about eight to ten seconds. It has been

thought that the trough of the wave, indicating low blood-pressure, coincides with an anæmic condition of the cells which refuse to work well in a starved condition.

Closely related to this topic is the *Span* of *Attention*, or the number of things that can be attended to simultaneously. Repeatedly has it been suggested that the answer to this is *one*.

If a number of dots or letters are exposed to the eye for a small fraction of a second, it will be found that several of them can be *grasped mentally* during this brief exposure, the number varying between two and eight, with the average about four. This number constitutes what may be called a *mindful*, and is directly comparable to the number of cartridges that may be held in a revolver. Only one of these can be brought into alignment with the barrel at a time; similarly only one of the ideas can be attended to at once. Others will follow in their regular order, and will be attended to in separate and successive pulses of attention.

Frequently the question of how many things *we can attend to at once* is confused with another — the number of things *we can do at once*. The answer to the first has been given — *one*. Yet we can *do* a considerable number of things at once, provided that they are habitual enough not to demand conscious control. For instance, a man can walk, talk, scratch his head, jingle his small change, and all the time be attending to some unrelated event happening in his immediate vicinity. This problem will be considered more in detail under *habit*.

Sustained attention, such as you are giving to this discussion, is always a succession of different pulses of attention either to different phases of the same idea as a consid-

eration of attention from the structural and the functional standpoints, or to a series of related ideas, as a perusal of the different phases and characteristics of attention as they have thus far been developed.

This ability results from the twofold capacity of attention to *analyze*, *i. e.*, to consider separately the parts of which a complex whole is made and to *synthesize*, *i. e.*, to group such parts into an organized whole.

The jeweller who is fixing a watch first *analyzes* it. He takes it to pieces and inspects each part — case, face, hands, wheels, pins, screws, etc. Each tooth on each cog-wheel and each thread in each screw has a separate existence and a separate consideration from him. When all is clean and new parts substituted for the broken, he *synthesizes* it, putting each part into its proper relations with others, and the assembled result is *one thing*, a timepiece. Similarly mind has the capacity of taking complex ideas to pieces, making the most minute subdivisions, inspecting each part of a part and then reassembling them to make a complex usable idea.

The causes influential in determining the direction of attention fall into three main classes. In order that these may be clear it is necessary that we take up first the nervous basis of attention, that is, draw a general picture of what is going on in the cerebrum when we are attending to a specific object. Whenever we are conscious at all we may picture the greater part of the cerebral cortex as active, but not all parts active to the same extent. There are degrees of intensity of nervous action as shown graphically in Figure 28. As indicated there, some one region of the brain is more intensely active than any other, and the ex-

perience resulting from the action of this brain region is the one that we attend to.

The whole secret then of controlling attention is in learn-

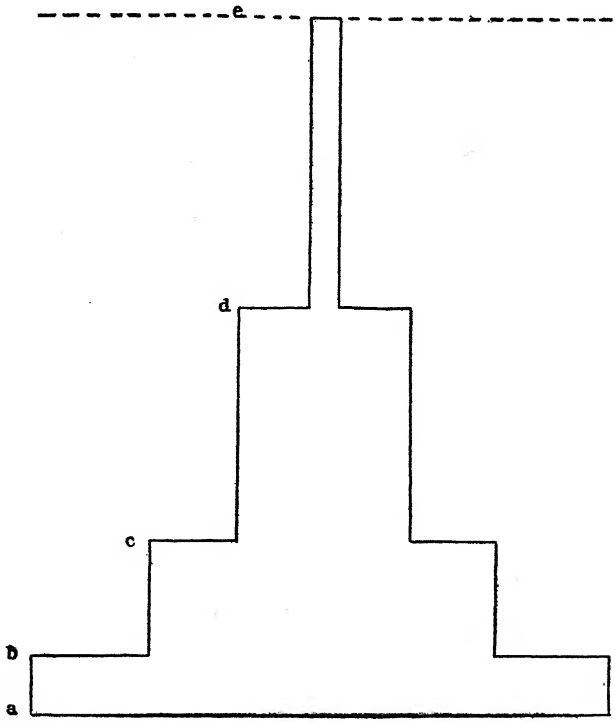


FIG. 28. Indicating the relative degrees of vividness in the field of consciousness. The entire figure from *a* to *e* includes the field of consciousness. *d-e* indicates the "bull's-eye" or attention, *c-d* the second ring, *b-c* the third, and *a-b* the fourth. Below *a* is the unconscious.

ing the laws which govern the amount of action occurring in any specific brain region at any specific time.

Such explanation reduces to three laws: The first con-

cerns itself with the intensity of the stimulus. Other things being equal, an intense stimulus will cause greater nervous activity in the part of the brain to which it goes than will a less intense stimulus. A graphic illustration will make this clear.

	Stimulus			
	A	B	C	D
Intensity of stimulus	25	20	15	10
Resulting brain action	22	17	12	7

The second principle involves a consideration of the resistance to be overcome by a nerve-current in its passage from sense-organ to brain. When two stimulations of equal intensity start from the sense-organ, each will use up part of its energy in overcoming the resistance of the synapses. Mechanically, then, that which has the greater amount of energy left when it gets to the brain will create the greater nervous response.

We now add this new cause to the previous diagram modifying it as follows:

	Stimulus			
	A	B	C	D
Intensity of stimulus	25	20	15	10
Energy used in passing synapses	10	3	8	4
Resulting brain action	15	17	7	6

The brain action already going on in that region is a

third determinant. In this case the amount of activity occurring in that specific region is added to the amount or intensity of the incoming stimulus, and the total action becomes the sum of the two. Furthermore, it has already been pointed out that an activity in a given cortical region automatically decreases resistance in those pathways leading to it. For strict accuracy, therefore, the figures in row 2, indicating resistance of synapses, should be decreased when the fourth row is added. A further addition to the table will illustrate this point.

	Stimulus			
	A	B	C	D
Intensity of stimulus............	25	20	15	10
Energy used in passing synapses..	10	3	8	4
Amount of action in brain region..	1	7	8	20
Resulting brain action..........	16	24	15	26

In the first case we attend to *A*, in the second to *B*, and in the third to *D*.

The factors controlling attention are, therefore, threefold, as already described.

1. Physical, resulting from the nature of the stimulus.
2. Physiological, resulting from the existence of "pathways" of low resistance in the nervous system.
3. Psychological, resulting from the present contents of consciousness.

The physical conditions, largely explainable in terms of intensity, are some five in number. They include:

Intensity in its various forms, comprising size and duration.

Quality of the stimulus.

Form.

Change; and

Motion.

The effects of some of these characteristics on attention have been carefully determined in the psychological laboratories, and definite laws have been worked out concerning them.

It has been found that the effect of the size of the visual stimulus upon attention varies as the *square root* of the *area*, when figures of similar shape are used. This means that if a certain size has one unit of attention value, the following relations hold:

Unit of Size	Attention Value	
1	1.00	(These numbers being the square roots of 1, 2, 3, 4, 5, etc.)
2	1.41	
3	1.73	
4	2.00	
5	2.24	

The quality of the stimulus has been found to have an effect upon attention value, that is, its likelihood of being noticed. Red has a greater attention value than green, blue than yellow, when seen against a white background. The reason for this is probably to be found in the time which it takes for the colors to stimulate the sense-organs. It has been discovered that red on a white background stimulates the retina in .006 of a second, blue in .009 of a second, and green in .012 of a second. Naturally enough, the stimulus

which first appears in consciousness is favored, for it adds to its own energy by attraction from other regions.

Little of a scientific nature has been done with the question of form as affecting attention, though it has been suggested that of two figures of the same area but different in shape, the more concentrated is the more likely to be noticed. A square, for instance, will have a greater attention value than a figure of the same area the ratio of whose sides is one to ten. The reason is that in the latter case the stimulus, in part, falls upon regions of the retina which are less sensitive, and, consequently, the total amount of nervous energy going to the cortex is less. Thus form obeys the first general law of intensity.

Change and motion are, to some extent at least, explainable in terms of the same principle. For the object in changing position, moving either forward or backward or laterally, is stimulating new and unfatigued parts of the retina, and consequently sends more stimulations to the brain than when the image remains upon one region.

Of the physiological conditions of attention are to be mentioned two general classes: those coming from our own individual past experiences and those attached to us because of hereditary causes.

In the first group belong our habits, both of thought and of action. Since habit results from repetition, the effect of repetition of a stimulus upon attention may serve as an illustration. Here we find a condition analogous to that already mentioned for size, since it has been ascertained that the effect of the frequency of the stimulus varies approximately as the *cube root* of the number of presentations. By computation, the cube-root law develops as follows:

NUMBER OF PRESENTATIONS	ATTENTION VALUE	
1	1.00	(These numbers being the cube roots of 1, 2, 3, 4, 5, etc.)
2	1.26	
3	1.44	
4	1.59	
5	1.71	

The physiological factor — decrease in resistance of synapses which results from the successive passages of the nervous impulses over them — is the explanation in this case.

Much more potent than simple mechanical repetition, however, is the whole group of what is known popularly as our "interests." Such "interests" represent conditions, objects, and relations to which we have attended in the past, and concerning which we have consequently a considerable body of knowledge. Knowledge, in whatever form it appears, is a function of decreased resistance of synapses. This is, nervously, the reason why attention is given to such familiar topics.

The hereditary causes of attending are likewise phenomena of decreased resistance of synapses. The more complete treatment of heredity will be left for the chapter upon "Instinct." Suffice it to say here that whatever is inherited is physical, be it bonds, blue eyes, or a liking for machinery, and the latter certainly is the result of inborn pathways of low resistance in the nervous system.

In the third group of conditions of attention may be placed the "present contents of consciousness." If on a large card be placed sixteen pieces of colored paper, four of red, four of yellow, four of blue, and four of green, and if the area of all be the same, exposure of the card to one

hundred different individuals will show that red is seen more frequently than green. Now repeat the same experiment with only one variation. Ask each person to tell you how many pieces of green there are on the card, and it is probable that at least half can tell you. Furthermore, at least forty will have noticed the green and but very few will have observed the red at all. The presence of the idea "green" in mind is sufficient to increase decidedly the likelihood of the green stimulus being seen.

Because of this analysis of the conditions of attention into three groups, we may infer the existence of three different forms or kinds of attention. Tradition sanctions such a division though it must be understood that the classification is based more on logical than psychological grounds. If our foregoing analysis is accurate, attention represents a condition of clearness, and it is doubtful whether three different kinds of clearness, one for each set of conditions, exists. Consequently, our subdivision must be taken to refer, not to differences in the attention process itself, but rather to the different causes or conditions which result in attention or in an alteration of the object of attention. And because the mental attitude in the one attending differs with the different conditions, the forms of attention have frequently been named from this standpoint; viz., involuntary, non-voluntary, and voluntary attention.

Involuntary attention, given because of the objective conditions of intensity, etc., comes unexpectedly, in the nature of a surprise. The ongoing attention process is interrupted, the train of thought is thrown off the track, and attention is directed to something new and unrelated to the previous subject of thought. Attention given to the tele-

phone-bell, the fire-engine, the honk of the motor-car horn is of the involuntary sort.

Voluntary attention appears when the subjective condition, the idea in mind, controls the direction of the stream of consciousness. Looking up a number in a telephone book is an illustration. Whenever there is intentional control of the course of thought voluntary attention is involved. Control, or at least self-control, can appear only when the idea in mind by its attractive power determines the selection and rejection of ideas as being relevant or irrelevant to the business at hand.

The acme of voluntary attention is found when two or more opposed ideas present themselves in consciousness simultaneously. We ought to study, we want to go to a moving-picture, and we can't do both at the same time. The idea of studying, as a subjective condition, arouses its sympathetic group of associates; similarly the idea of the picture summons its group of allied associates. A sort of mental bargaining results; each constellation of ideas is given a value, this value being a sort of emotional response to the total situation involved. The group having ascribed to it the greater value eventually wins, its opponent becomes less dominant, and the normal course of voluntary attention follows.

Non-voluntary attention results from the physiological conditions and in essence is voluntary attention become habitual. Routine of all sorts, where one idea leads to another because of open nervous pathways without demanding an anticipatory idea in mind, is of this sort. Signing your name, singing a familiar song, reciting an old favorite are examples of this form of attention.

Accompanying each shift in direction or intensity of attention are to be found changes in muscular adjustment. In fact, from one's posture and attitude, it is possible to tell whether or not a person is attentive. These movements fall into some four classes. At times all four types of adjustment are present, sometimes only one or two; but certainly all may be present in any act of attention.

In one group will be included adjustments of the sense-organs in such a way as to facilitate observation. The eyes are turned to the printed page in reading a book; to the behavior of the players in watching a game or contest of any sort. In listening to sounds, the head is turned so that the sound may be perceived as clearly and distinctly as possible. Examples of other situations in which movements of tongue, nose, etc., occur to make the conditions as favorable as possible for the reception of the incoming stimulus will occur to every reader. Even in thinking of objects not present to the senses, that is in memory and imagination, similar movement tendencies may be observed.

In a second group would come certain inhibitions of movement. That is to say the movements of adjustment tend to be limited to the sense-organs involved in the attention act, and other movements which would interfere or distract are as far as possible eliminated. When listening to a faint sound, the body is held rigid, for body movement makes sound, a condition unfavorable for the perception.

In a third group would come the tendency to imitate the object or idea attended to. The spectators at a football game may be observed to lean in the direction in which their team is trying to carry the ball. Even more striking is the experiment performed by Jastrow. One person concealed

an object—book, thimble, or hat—somewhere in the room. He then took his place at a planchette or ouija-board and thought of the position of the object. When the record was examined, it was found that he made slight, unconscious arm movements, which, when added one to another, indicated the direction of the object from himself and enabled the others to go straight toward it.

In a fourth group may be included organic changes, the readjustments of the mechanisms of circulation, breathing, digestion, and glandular action. With increasing rigor of attention, in going from an easy to a more difficult task, for example, phenomena similar to those occurring in physical work are discovered. The heart tends to beat faster, the breathing becomes more rapid, the sweat-glands are stimulated to increased activity. When the change is in the opposite direction, from a difficult to an easier task, the symptoms are reversed; the heart rate becomes slower, breathing retarded, and the sweat-glands less active.

What is the value of these movements? It has been suggested by some that they serve as a sign or index of attention; that by measuring the vigor of the movement it is possible to get a measure of the concentration of attention. This has been questioned because the movement, when it becomes too violent, acts as a distraction and diverts attention.

It seems more probable that the real function of the motor accompaniments of attention is not to act as a sign of attention, but rather to aid and abet the process already going on. It seems entirely plausible to assume that any active brain region not only radiates energy onward toward the association and motor areas of the nervous system, but

also attracts nerve-energy toward itself, the amount of attraction depending upon the intensity of the nerve action. If this is the case, the muscular and organic brain regions must afford a supply of energy which, in part, goes over to the motor region, thus serving for the continuation of the muscular adjustment, and in part is attracted into the most active brain region. Arrived there, it enhances the resulting conscious process, making it more clear, distinct, and enduring. The motor processes which accompany attention have as their function, consequently, the enriching of the attention process and making it more enduring.

To summarize: Attention is the name used to describe the series of cognitive experiences which dominate consciousness. Of the host of sensations, perceptions, and memories which are constantly assaulting consciousness, some are of more importance to the individual than others. Intensive stimulations may mean danger, consequently they demand attention which is given involuntarily. Likewise our present plans and purposes seem important to us, and consequently are attended to. We attend to those things which seem important to us and disregard the rest. Throughout body co-operates with mind to render the attention process more prominent and longer enduring.

PROBLEMS

1. How can you account for "clearness" in attention?
2. In what sense is attention a selective process? What does the selecting?
3. Relate the "target" diagram of the cross-section of consciousness to the pattern of consciousness.
4. Is attention a simple or a complex process?
5. How does the principle of "attraction" account for voluntary attention?

6. Is a large advertisement or a frequently repeated one more likely to be attended to?
7. What types of movement usually accompany the attention process? What are their functions?

CHAPTER VIII

CONCENTRATION

CONCENTRATION is the word used to indicate the degree of intensity of the spontaneous and voluntary forms of attention. In the stream of consciousness illustration, concentration may be pictured as a narrowing of the banks which deepens the stream and makes it run deeper and faster. The increased speed with its greater momentum makes the stream a more potent force — one which can turn the ponderous wheels of business, one which can overwhelm more serious obstacles, and one which withal runs straight to its goal unswerved by petty disturbances.

As has been indicated, attention is essentially a selecting process whereby an idea is rendered more clear and distinct in consciousness. The amount of concentration is either the difference in degree of clearness between the idea attended to and those of which we are merely conscious, or, expressed differently, is our capacity to inhibit and exclude ideas which are irrelevant to the main train of thought.

Concentration, consequently, is the reverse of distraction. It is the capacity one has of resisting the disturbing elements which, when noticed, result in involuntary attention.

Furthermore, concentration is a form of spontaneous or voluntary attention which is sustained upon one general topic for a comparatively long period of time. Apparently, also, the mind works faster during concentration than it does during periods of dispersed attention.

The degree of concentration may be represented graphically by the perpendicular line between the top of the stairs and the step next to it, as shown in Figure 29. Concentration, then, is the ability to focus or direct our minds definitely upon one thing to the practical exclusion of all others.

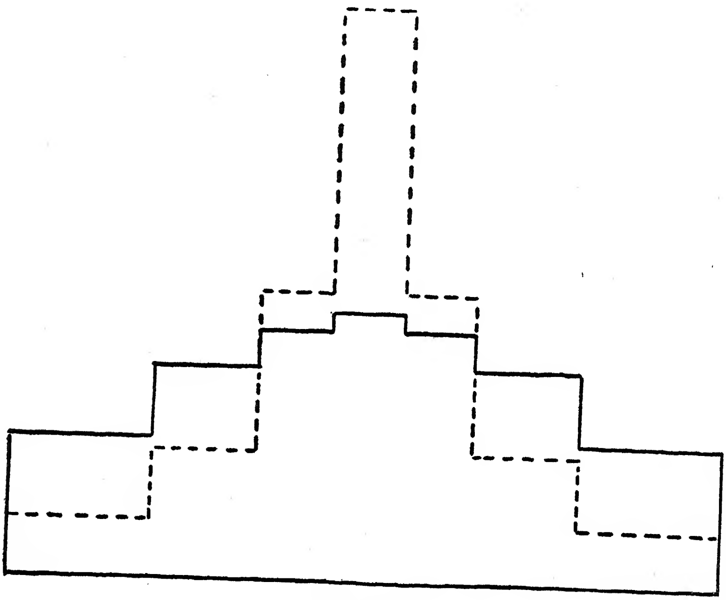


FIG. 29.

Other things will never be entirely excluded. This is psychologically impossible, for the result would be, not concentration, but unconsciousness. It is axiomatic that concentration never is perfect, but is always a relative, rather than an absolute, condition.

The degree of one's concentration is difficult to determine by any orthodox test. The following suggestion has been used in the psychological laboratories. Give a person a certain job to do. Add a column of figures, for example, in a room where there is no disturbance. Find out how many columns he can add in ten minutes.

After resting a few moments let him resume adding, this time with a slight noise in the room where he is working. It may be no more than the clicking of a typewriter, but that will serve as some distraction. Under these conditions, record the number of columns added in ten minutes. After another rest, let him repeat a similar task where there is more noise; where, for instance, conversation is going on. It is probable that a novice will show greatest efficiency where there is slight noise, and considerable lack of efficiency where there is more distraction.

Individuals differ widely in their ability to concentrate. Some never develop it. Others can apparently work as well when surrounded by all kinds of distraction as when in silence and alone, depending in part upon the duration of the concentration, and in part upon the capricious or logical order of the ideas concentrated upon in separate pulses or groups of pulses.

KIND OF CONCENTRATION	TIME DURATION	RELATION OF IDEAS
1. Periodic	Medium	Related by external conditions
2. Spasmodic	Short	Related by caprice or chance
3. Impulsive	Short	Related by external conditions
4. Continuous	Long	Related by logical succession

One kind is periodic concentration, a form demanded of the person who has many short yet similar tasks to perform

one after the other. Examples of this form are: a student preparing a lesson, a bookkeeper adding a column of figures, a lawyer preparing a brief. This is the one most frequently demanded form of concentration in practical life.

Many inventors have periodic concentration. They are extremely interested in one thing for a while, then turn to something else. They go back after a few months to the scheme which they previously had abandoned. Apparently this shifting is not so much a result of inability or unwillingness to master difficulties as it is a matter of interest pure and simple. Many stories are told of the inventor of the *Monitor*, Ericsson, showing how he jumped from one problem to another and back again. The same is true of so many inventors that it is almost axiomatic. Similarly the educative tendency of the present day with the student jumping from mathematics to history, then to language, then to science, is decidedly in favor of periodic concentration.

When one phase of periodic concentration is followed by another directed to a topic which is not only widely different, but which is evoked by the caprice of the individual rather than the demands of any practical situation — it develops into *spasmodic concentration*. It manifests itself in two forms:

One is day-dreaming, mind-wandering, and the like, in which mind, while sufficiently concentrated, suffers from lack of a definite goal to work toward, thus making side excursions and "the easiest way" the natural result.

The other is a superficial flitting from topic to topic, from interest to interest, from desire to desire, from irrelevance to irrelevance. Those who are afflicted with this

form of *spasmodic concentration* are the victims of fads, new cults, and other systems conducive to mental indigestion. The consequent repugnance causes them to seek relief in any highly seasoned form.

On the other hand, when one phase of *periodic concentration* is followed by others whose course is determined by outward circumstances pertaining to the work at hand, it may be called *impulsive concentration*. This is of very great importance for it measures the ability of a person to jump quickly and repeatedly from idea to idea. The executive, who must settle a number of very different problems hourly, who must be interviewed by a corps of different persons with diverse difficulties, who must answer a bewildering assortment of letters dealing with the utmost diversities of situations, must have this ability. The demand for impulsive concentration is absolutely destructive to the efficiency of some types of mind, whereas with others it seems to be an asset rather than a liability. An actual example illustrates how important it is that individuals should know their tendencies and work at jobs suited to their abilities. This man had a job in a factory which demanded that he attend to the remarks of one workman, and then another, and when there were no demands of this kind upon his time he was supposed to plan ahead the work for the different machines. No sooner would he get started planning than a workman would come and demand another job. Even before his case was settled a second appeared and frequently a third and a fourth. This constant shifting from one train of thought to another, he found to be extremely irritating, extremely destructive to his efficiency, so much so in fact that he was forced to give up that posi-

tion, and seek another which matched his mental make-up in a more satisfying manner.

Whether one belongs to this type or not can ordinarily be determined by a very simple means. Most people already know it. But in case any one does not, let him perform the experiment outlined on pages 143–145.

When one phase of periodic concentration is followed by others which deal with subjects intrinsically related, it develops into *continuous concentration*, the sort which enables a man to sink himself into one problem or in one line of thought for a long period of time, as did Edison when working on one of his inventions. It is probable that such concentration is really habitual — that after some training it is no more effort to attend to a previously difficult task than to a novel or interesting moving-picture drama.

One of the best examples of *continuous concentration* is that of the Dutch physiologist, Zwaardemacker, who investigated the sense of smell. In performing this experiment it was necessary to exhaust the nose for one odor, *i. e.*, camphor, by smelling continuously until all scent had disappeared, and, in turn, when the nose was thus exhausted for camphor, to sniff another of the several hundred odors. The nose had to be re-exhausted for camphor before each of the other odors in turn was smelled. When this long list was completed for camphor, he repeated it for beeswax, and so on in turn for all of the various odors.

But before he could do this it was necessary that he become thoroughly acquainted with the exact odor of each of the substances. This work consumed a mere trifle of ten years. Anything more uninteresting is difficult to conceive. The ability to stick to it, to carry it through even at

that expense of time and effort makes it a noteworthy illustration of concentrated attention.

We may include also *absorbed concentration,* a condition usually known as absent-mindedness. In reality there is no such thing as absent-mindedness. It is present-mindedness to some other topic. We may say a student is absent-minded when he refuses to listen to our interesting lectures, but if we investigate we find out that he is definitely and deeply absorbed in some of his own hobbies.

The teaching profession is, of course, remarkable for its absent-mindedness. It is said that Francis Galton, a British scholar of much repute, while walking in the streets of London deeply absorbed in an abstruse problem, turned to one side to allow some ladies to pass. He had one foot on the curb and one in the gutter. In his abstraction, he walked for several blocks in this position. Suddenly as he neared his house he became aware that he was lame and sent immediately for a physician.

ADDITION-SUBTRACTION TEST — TO TEST TYPE OF CONCENTRATION

For 1 minute, add 17 to each number in column 1 and write the answer in the blank opposite the number.

For 1 minute, subtract 17 from each number in column 2 and write the answer in the blank opposite the number.

For 1 minute, subtract 17 from the first number in column 3, add 17 to the second, subtract 17 from the third, add 17 to the fourth, and so on adding and subtracting alternately. Record the answer in the blank opposite the proper number.

For 1 minute, in column 4, subtract 17 from the first

number, add 17 to the second, subtract 17 from the third, add 17 to the fourth, etc.

For 1 minute, in column 5, subtract 17 from the first number, 17 from the second, 17 from the third, 17 from the fourth, etc.

For 1 minute, in column 6, add 17 to the first number, 17 to the second, 17 to the third, 17 to the fourth, etc.

	ADD 17	SUB. 17	SUB. ADD 17	SUB. ADD 17	SUB. 17	ADD 17
1	64....	18....	96....	38....	85....	19....
2	81....	46....	19....	41....	32....	55....
3	42....	79....	81....	72....	38....	28....
4	19....	28....	42....	69....	56....	46....
5	96....	30....	64....	24....	41....	81....
6	55....	55....	33....	46....	27....	24....
7	37....	96....	79....	28....	72....	69....
8	28....	19....	18....	55....	45....	72....
9	79....	42....	91....	32....	69....	41....
10	46....	81....	45....	56....	91....	38....
11	18....	64....	20....	23....	24....	85....
12	24....	24....	56....	45....	18....	96....
13	91....	91....	32....	91....	46....	30....
14	69....	69....	55....	18....	79....	79....
15	45....	45....	28....	79....	28....	18....
16	72....	72....	46....	33....	37....	42....
17	27....	23....	24....	64....	55....	64....
18	41....	41....	69....	42....	96....	91....
19	56....	56....	72....	81....	19....	45....
20	38....	38....	41....	19....	42....	23....
21	32....	32....	38....	96....	81....	56....
22	85....	85....	85....	85....	64....	32....

When you have completed the experiment, treat the results in the following way:

1. Add the number of problems done in columns 1, 2, 5, and 6. Divide the number by 4. Call the answer *A*.

2. Add the number of problems done in columns 3 and 4. Divide this number by 2. Call the answer *B*.

3. Divide B by A. A shows your mental speed when you are doing the same kind of mental task continuously. B likewise shows your mental speed when you are forced to change your mental adjustment at every step. If B equals A or is greater than A, it shows that you can make such readjustments readily.

If A is much greater than B, it indicates a tendency to become rattled when quick mental shifting is necessary. The greater the fraction resulting from the solution of the equation $\frac{B}{A}$, the greater is the readiness of the person to undertake tasks involving impulsive concentration; the smaller the fraction, the less prepared he is for such tasks.

Undoubtedly practice will be of some benefit in bringing about improvement, but how far this will be really effective is in dispute.

As far as practical results are concerned it apparently makes little difference which types of concentration one possesses so long as he is able really to concentrate. Each of the types, of course, has its limitations and its advantages.

Furthermore, if we were to grade accurately a group of people we should find that each individual possessed each of the types to some extent and used each one in certain particular situations. By training he can develop in any given situation the type which is demonstrated to be the most effective. Furthermore, if we consider one concentration type we should find individuals varying all the way from practically zero per cent to 100 per cent. Either extreme is probably bad. Exactly the same remark may be applied to any or all of the other types.

Much to be despised is the weak-kneed sort of concentration which falls down before it is really started. It

results in nibbling at many things and doing nothing. As far as accomplishment is concerned, it has no effectiveness whatever.

The writer knows a man who, many years ago, went to Germany to work for the degree of Doctor of Philosophy, a task which ordinarily takes three years. This seeker after knowledge was enthusiastic and earnest. He attended lectures day and night and spent hours in the library. But he returned to the United States at the end of seven years without his degree.

He had brains to spare and an unequalled amount of industry. But he was unable to decide upon a topic for a thesis. One teacher suggested an experiment on color-blindness which filled him with enthusiasm until another master pointed out a second. He nibbled at this for a few weeks, but came across a third topic in his reading which seemed more promising. This habit of nibbling and running away to nibble at something else proved to be his destruction. For eventually the authorities got tired of it and sent him home.

This man's experience is typical of thousands in industry, men who never stay at one job or in one department or with one firm or in one line of business long enough to master the job. Their going about is not in the nature of advancement from position to position because the previous work was well done, but a changing about for a lack of concentration. Soon their employment record and long list of references even become a liability. Sooner or later many people with this scattering type of experience come to realize very sharply that they must "settle down" to some one thing, that is, concentrate.

As has already been pointed out, distraction is the enemy of concentration. For this reason, much attention has recently been paid to the problem of noise in industry. The use of the noiseless typewriter and the deadening of walls and ceilings with sound-proof material have been found to be a very great aid to the efficiency of workers. Not infrequently when a worker has been changed from a noisy to a quiet place, his increased efficiency amounts to as much as thirty-five per cent.

Experiments in psychological laboratories suggest that a certain amount of distraction may, and usually does, have a favorable effect upon quantity and quality of work turned out. The greater output is, however, at the expense of increased exertion — suppressed articulation of words, greater pressure upon pencil or other implement being handled, etc. The laboratory experiments, however, have been of too short duration for the results to be greatly affected by the fatigue which follows inevitably the augmented effort. That added fatigue is present is undoubted. That it does have an effect when continued for long hours at a time is amply demonstrated by production records.

Nor can we constantly concentrate upon any one thing for a very great length of time. With even the most sustained concentration this is impossible. Fatigue appears and, as a result, decreased concentration and correspondingly greater distractibility, until before we know it attention is turned to something else. Also, as we have seen already in the discussion of attention, we can attend to the same idea or object for only four seconds. If concentration ever endures for a longer period than this, it must concern itself with new fresh waves of activity, relating the present ideas to others.

Summary: Concentration is attention of a high degree of clearness. The superlative clearness is brought about by the combined forces of facilitation and inhibition. The fact that concentration is involved in purposeful thinking of all kinds implies the existence of a plan or intention. Such a mental process is correlated with nervous action which, because of its attractive force, tends to focalize and facilitate the appearance in consciousness of ideas leading to the desired end. Other unrelated ideas are inhibited, or excluded. Furthermore, the muscular adjustments accompanying attention aid in facilitating the favorable and inhibiting the unfavorable ideas.

When attention is concentrated the stream of consciousness apparently flows faster and with a greater "head." This probably is owing to the greater intensity of the correlated nervous activity, for a strong nerve-current crosses the synapses more quickly than a weaker one.

Depending upon the situation which calls it out and also upon the subjective adjustment of the individual, concentration may take any of a number of forms. As we shall see in a moment, concentration is closely related to interest.

PROBLEMS

1. Compare attention and concentration.
2. What is the rôle of the attraction principle in concentration?
3. What are the effects of distraction on concentration?
4. Under what conditions can you concentrate most easily? Why?
5. Can you turn your attention rapidly and effectively from one task to another? Why?
6. Which of the above types of concentration do you most frequently use? What are its advantages and disadvantages?

CHAPTER IX

INTEREST

THE foregoing analysis has shown that attention is the simultaneous awareness of the entering impression and of the idea-in-mind. The entering impression, to linger at all in consciousness, must form a connection with what is already there, either actually or potentially. Such connections are furnished, first, by the present congruous contents of consciousness — a condition known under the various names of perception, recognition, cognition, and meaning; second, by retained experiences not at the moment present in consciousness but liable to rearousal, a condition which has been called apperception. In either case, personal individual experiences are necessary. Instincts in their first appearance are inadequate, for they result essentially in activity, thus possibly causing sequences of sensations, but certainly not immediate centrally aroused processes.

Our normal adult attention is essentially a relating activity, a bringing together of the incoming and what is already there. As we have already seen, the incoming is the direct result of a *vis a tergo* and so may be spoken of in a figurative way as a "push from behind." Similarly, the present content of consciousness, in so far as it exerts a selective influence on the presented sensations, emphasizing one and rejecting others, may be said, again figuratively,

to exert "a pull from ahead." Attention then results from an interplay of these two forces and is consequently not a simple elementary process, but complex. In that it consists of two mental processes, it is analogous to association. In fact, it would appear that instead of attention being the unit of association the association process is the unit of attention.

A word of qualification is necessary at this point. Associations may be divided into two classes, those which operate simultaneously or instantaneously and those which operate in succession. In the latter class would be included memories, delayed recognitions, and the like. In the former would belong perceptions, immediate meanings, immediate recognitions, and the like. Attention would, then, depend upon the former class of associations. The latter would result in successive pulses of attention. What is meant is that attention is complex in the same sense that perception is; the fact that it is possible to attend to a percept proves this automatically. But memory images, on the other hand, are attended to in successive pulses.

Since attention is a complex resulting from a combination of the "push from behind," which initially is sensory, and the "pull from ahead," which is necessarily central, it is pertinent to ask whether the fact can be used to explain any of the peculiarities of attention and allied phenomena.

Interest is the one topic concerning which there has been so much disagreement as practically to force it outside the realm of theoretical psychology. The reviews of "Attention and Interest" are inclusive on attention and microscopically brief on interest. This is extremely unfortunate, for an understanding of the laws and principles of interest is of

great importance, both practically and theoretically. The view-point already expressed that attention is essentially a complex process, offers a somewhat different angle from which to approach the problem.

The first thesis is, that interest results only from the complex form of attention.

Pillsbury, in his discussion, identifies interest with the causes or effects of non-voluntary attention, giving as conditions all of the subjective group, except social forces. He, therefore, tacitly admits that in interest there are two processes, the incoming and memories, actual or potential. As has been stated previously, the first appearance of the instinct, for example, can be accompanied by no characteristic centrally aroused process and consequently the so-called native interests are impossible in the strict meaning of the term. With animals having memory, however, subsequent arousals of the instinctive tendencies may call up memories and hence may be interesting. Whether these shall be called native interests is merely a question of terminology. The essential point is that individual past experiences, existing either as present contents of consciousness or as associative tendencies, are essential for the appearance of interest.

Strictly speaking, the primary form of attention resulting from the "push from behind" cannot be interesting, for it is a mere passive awareness without meaning, purpose, or future reference.

It appears, then, that if there are two forms of attention, one of which from its very nature is uninteresting, interest, if it exists at all, must be a function of the other or complex form.

It does not follow, however, that interest is a function of all forms of complex attention. The evidence goes to show that the complex form of attention sometimes is interesting and sometimes is not. This leads directly to the second point.

The second thesis is, that interest results only when the complex form of attention consists of a relatively old and of a relatively new process.

The "push from behind" and the "pull from ahead" can be divided into the old and the new. Such classification must be understood to suggest a relative difference only, for the border-lines which separate the new from the old and the old from the new are too shifting to permit of any hard-and-fast division.

Another bit of evidence pointing to the fact that attention reaches out for the new is quoted by Pillsbury.[1] "In determining the part played by eye movement in the perception of depth, Helmholtz had occasion to make a number of experiments on the influence of successive illumination of the field of vision by the electric spark. . . . At first only a very imperfect image of any part is received. With each succeeding spark a greater amount of detail is perceived, until a clear image of that region is obtained."

Since sustained attention is impossible without interest, it follows that when attention, as in a psychological experiment, must be sustained the subject seeks the interesting. In Helmholtz's experiment this was obtained by the mental reaching out for the new.

A logical classification of the old and the new as related to the "push from behind" and the "pull from ahead," to-

[1] Pillsbury, "Attention," pp. 33–34.

gether with their psychological names, is given in the following form:

PUSH	PULL	PSYCHOLOGICAL NAME
old	old	recognition.
new	old	meaning, cognition.
old	new	originality.
new	new	no name; probably no existence.

Recognition, as a process, the relating of the old with the old, is believed by many to be pleasant, but the writer has yet to find an assertion that it is interesting. Yet meanings, cognitions, new ideas, and new discoveries may be and are interesting.

One of the biggest psychological laboratories for testing in a practical way the principles of attention, interest, desire, belief, and volition, is found in advertising. A method made public by Kitson in 1921 and used by the writer since 1913 in the investigation of advertising problems, depends upon the assumption that advertising tendencies which are successful tend to persist, whereas those which are unsuccessful tend to disappear, the result of natural selection and survival. Since one of the necessities of successful advertising is the arousing of interest, it will be illustrative at least to compare the percentage of advertisements used now which give information, which present the new, as compared with those of a decade ago. A study of this kind is reported by Kitson.[1] Analysis of 1,000 advertisements contained in *Collier's Weekly* for 1902 showed that twenty-two per cent were informative in character. A similar study

[1] Kitson, "The Mind of the Buyer," p. 79.

of the same medium for 1919 revealed that seventy-four per cent were informative. This increase of fifty-two per cent in seventeen years in information-giving advertisements is an illuminating illustration of the psychological principle involved if the increase has been at all constant and regular.

By experimental evidence it has been shown that interest may be present when the old and the new are brought together in consciousness. By accepted terminology it has been demonstrated that when the old and the old are brought together, interest is lacking. By exclusion, then, interest can appear only when the old and new are brought together in consciousness.

It does not follow, of course, that interest is always experienced when the old and the new are brought together mentally. Other limitations are necessary, and the ones most immediately suggested concern further relations and peculiarities of the old and the new.

The third thesis is that interest results only when there is congruence between the incoming and the present contents of consciousness, either actual or potential.

This proposition divides immediately into two parts. The first condition exists when the idea in mind selects incoming impressions congruous with it. The second condition exists when the powerful entering experience finds nothing at the moment in consciousness congruous with it, and is forced for self-preservation to make central connections of a congruous sort.

Concerning the first form, little need be said. Pillsbury,[1] in his discussion of the idea in mind as a subjective condi-

[1] Pillsbury, "Attention," pp. 33–35.

tion of attention, cites a large number of examples taken from the experimental literature and gives many every-day illustrations. To his data may be added the evidence derived from the complication experiment and certain practical evidence obtained from advertising. Walter Dill Scott, in his investigations of the relative effectiveness of the segregated advertising section as compared with advertisements mixed with reading-matter, found that, "Space next to reading-matter is more valuable than space in the segregated advertising sections for advertisements of silk if the advertisement is placed next to an article on dresses or interior household decorations; for advertisements of seeds, if placed next to an article on gardening; for advertisements of almost any class of goods if placed next to an article dealing with the use of the goods advertised." This certainly is an excellent illustration of congruence.

When the incoming impression, however, is more potent than the cortical set or predisposition and when there is also a lack of congruence, involuntary attention is the inevitable result. The process thus attended to either fades promptly from consciousness or must make contacts with congruous elements of past experience then lying dormant. This, when accomplished, is a condition of non-voluntary attention, but between the involuntary and the non-voluntary there is frequently, if not always, a period of voluntary attention. There is, in this situation, therefore, no immediate interest; in fact, the interest appears only when the incoming has become subordinated to the processes of central origin.

A further limitation of interest is given in the following thesis.

The fourth thesis is that interest has a future reference or implication.

It has already been pointed out that interest can appear only when the old and the new are brought together in consciousness. The only basis for anticipation, expectation, and forward projection in time is found in some record of the past. Such data come most immediately from memory, and memories certainly are in our terminology old. When the old is joined with the old as in recognition, interest is lacking. Only as the old is used to interpret or give meaning to the new does the process become interesting. For a thing means not only what it is in an abstract sense, but more vitally what it can do; and what it can do is a potentiality, an implication of something to come.

An example is furnished in Münsterberg's investigation of monotony.[1] He selected, for observation, those tasks which appeared to be the most monotonous and then asked the worker whether or not the work was interesting. The report of the woman who packed electric-light bulbs is especially informing. For the past twelve years she had packed 13,000 lamps a day, a total of about 50,000,000. Yet, says Münsterberg, "She assured me that she found the work really interesting, and that she constantly felt an inner tension, thinking how many boxes *she would be able to fill* before the next pause."

Kitson, in the study previously mentioned, divided the kinds of information given by the advertisements into four classes and determined the percentage of each used in the two years compared. His results are appended in the table following.

[1] Münsterberg, "Psychology and Industrial Efficiency," p. 196.

	1902	1919	GAIN OR LOSS
Uses	57	66	9
Process of manufacture	22	14	−8
Personnel of firm	11	18	7
Sources of raw material	10	02	−8

Information pointing to the future, that is, uses, holds the first place. In seventeen years it had gained in popularity as has also information about the personnel of the firm. It will be observed that the two categories, process of manufacture and sources of raw material, have fallen off in use. It will be further noticed that the emphasis with these two categories is upon the past tense. The relative frequency with which these four categories are used varies directly with their future reference.

But both past experiences and future references can be divided into those which are pleasant and those which are unpleasant. Concerning these a similar generalization can be made. In relating the old to the new one should give that sort of the old which has had on the average pleasing after-effects and may be expected to do so in the future. This point is illustrated adequately by the manufacturing concern which was ready to launch an intensive selling campaign of an article to keep the feet warm in cold weather. Since the article was intended for those who suffered from cold feet, it was naturally directed to them. To arrest their attention the following head-line was used — COLD FEET. For some mysterious reason the article did not take. The advertisement was submitted to an expert for criticism. He decided, and rightly, that persons who suffered from cold feet were not interested in them, but would be much

interested in warm feet. So the head-line was changed to read WARM FEET and the remainder of the advertisement was left untouched. Sales began to pick up immediately. Cold feet were a present condition, and to that extent both uninteresting and unpleasant. Warm feet were a future possibility and for that reason interesting.

On the reverse side, common observation tells us that when we may expect only a repetition of the same old thing, interest tends to lapse. The behavior of the spectators at any athletic contest is an illustration. When the game is a "walk-over," so that they may look simply for a repetition of what has already been done, large numbers leave the contest before it is over. But when the game is close and anything is likely to happen, they tend more strongly to remain to the finish.

Closely allied to this topic is the next proposition.

The fifth thesis is that the interest attaches to the ends, not to the means to the ends.

Rigid definition of terms is important in this connection. The term "end" will be used to mean the mental representation of some goal which is to be accomplished; "means" include the physical or mental operations necessary to accomplish or realize the end. Obviously, then, the terms can be used only in a relative sense, for, as mental attitude shifts, an end may become a means or a means an end. For example, I may desire to learn a new dance step. The learning is the end or goal. The means to the end consists in locating a dancing-master, making an appointment. So much of this procedure is old, a mere routine or habit, and is, therefore, not interesting. But the trial and error which follows, making the same old feet behave in a new way,

introducing a new order into the same old movements — that is interesting. When the movements become automatic, interest in them lapses. The dance step becomes a means to a different end and interest attaches to the end.

But not all ends are equally interesting. Some of the influential factors have already been given; others remain to be considered.

The sixth thesis is that interest tends to attach more strongly to the more immediate ends.

This follows immediately from the very nature of attention itself, for it is impossible to keep long and consistently in mind the idea of any end. At best, the remote end can manifest itself as an attitude or purpose, and there is good ground for believing that the present content of consciousness is more effective as a selective agent than is cortical set alone. In most cases, in fact, it is possible to retain interest in a remote goal only by the interpolation of a series of more immediate ends.

If the words "immediate" and "remote" are used in a spatial as well as a temporal sense, the use of examples is, perhaps, the more effective. Judging from the contents of their sheets, the newspaper editors believe that the fractured arm of a neighbor is as interesting as the slaughter of scores of persons on the other side of the globe. Doings remote in time or space are ordinarily of but little concern to us. As Pillsbury[1] says: "We find that we are interested in those things most closely related to our own past life. We are interested in the 'local' items of our own town paper, while similar items when read in the paper which we pick up on the table of a friend seem ludicrous in their

[1] Pillsbury, "Attention," p. 53.

puerility. A student is interested in anything that is new to him, but at the same time is so closely related to the things which he has known before that he has no difficulty in connecting it with some previous bit of knowledge. And the closer the connection, and the more important to the person the things with which it is connected, the stronger is the interest." This surely is but another way of stating our next thesis, which needs no further demonstration.

The seventh thesis is, that the centre of interest is the self.

Two other problems remain to be considered. The first is analogous to the old question: Is there sound where there is no ear to perceive it? Is the interest in the event or in the perceiving individual? Possibly the whole question as stated in this form is one of definition. The implication is: Are there certain events or objects which tend to be universally interesting, or is interest entirely subjective and personal? It may be argued that, since we have a common fund of experiences provided by way of instincts, and since also agreement as to what is interesting may be due to prestige of leadership, situations calling out such expressions will be interesting. But the objection is that these common events become interesting only after experience and that then the interests become varied. It is the nature of the past experience and the demands of the present situation which determine interest.

Münsterberg's[1] researches on monotony have a direct bearing on the problem. It will be recalled that he found persons engaged in the most uniform and apparently monotonous tasks who took interest in them, whereas others

[1] Münsterberg, "Psychology and Industrial Efficiency," pp. 195–205.

whose work offered apparently the greatest possible variety found them to be monotonous and boring. Speaking of a classroom experiment, he says: "We found that in the whole student body there was a tendency to underestimate the number of the similar or of the repeated words. The majority of my students had a stronger impression from the varying objects than from those which were in a certain sense equal. Yet this tendency appeared in very different degrees, and for about a fourth of the participants the opposite tendency prevailed. They received a stronger impression from the uniform ideas. . . . I found that just the ones who perceive the repetition least hate it most, and that those who have a strong perception of the uniform impressions and who overestimate their number are the ones who, on the whole, welcome repetition in life."

This quotation emphasizes not only the fact of individual differences in interest, but ascribes a reason for them, showing how they result from the inner constitution of the person. We are forced to agree with Pillsbury[1] that "Interest then is not dependent upon the object, but upon the nature of the man to whom the object is presented."

The remaining topic has to do with the relation between interest and affection. Some authors contend that interest is a feeling, a pleasant attention. If that is the way they define interest, they are undoubtedly right, but they certainly are at variance with the ordinary meaning of the term. In its usual connotation, interest may be either pleasant or unpleasant. One may be interested in the football scores, he may be interested in the technic of a play or novel, he may be interested in the rise of his temperature,

[1] Pillsbury, "Attention," p. 54.

or in the operations of his dentist. In some cases his interest will be pleasant and in others unpleasant. In so far as interest is related to anticipation, it would be incorrect to say that it is always pleasant. Interest may have the same degree and quality of affection as any other sensory or ideational material.

But since interest does point to the future and tends to lapse when the goal is attained, is anything left other than an awareness of the end? Apparently when the goal is reached and the interest lapses or shifts elsewhere, an after-glow either of pleasure or displeasure remains for a time. When the dance step is learned, the interest abates, but the pleasure increases; when the touch-down is scored the interest wanes, yet the pleasure is augmented.

Throughout the whole discussion it is necessary to distinguish between the interest and the pleasure. A succession of tones, listened to merely as a succession, without anticipation of what note is to come next, without interpretation, without reference, may be pleasant but not interesting. Similarly, recognition is uninteresting but pleasant when the activity stops short with the recognition. The old, the past, is uninteresting in itself; the present is uninteresting; only the future is interesting.

Summary: Interest, we see, is essentially a mental examination of objects, conditions, and situations, a sampling, a tasting, in which the self is not completely identified. It partakes more of the nature of a consideration of potentialities than of actualities and answers the question, Is this worth while for me? Tinted more with emotional content than attention, it represents a further narrowing of the field of consciousness. When the mental examination re-

sults in a belief in the value to the self of the object, situation, or condition, a further narrowing of the conscious field, accompanied by an increased emotional content, results. This is known as desire.

PROBLEMS

1. Which of the three forms of attention involves interest?
2. What in addition to attention is necessary for interest?
3. Are there instinctive interests?
4. Is an anticipatory idea necessary for interest?
5. Are all anticipatory ideas interesting? If not, what else must be added?
6. How can you account for the interest of one human being for another? Why does this usually decrease with time, distance, and the number of persons about us?
7. Consider the books and newspaper stories you have found interesting. Do they follow the laws of interest as outlined in this chapter?
8. What type of story do you find most interesting? Why?

CHAPTER X

PERCEPTION

IN previous chapters we have dealt with the raw materials of consciousness by way of sensation and image. We have shown how succeeding experiences became associated so as to form series of mental processes of the sort found in recall and memory. In these situations we have one discrete, distinct process followed in time by another; the association is *successive*.

We must now turn our attention to *simultaneous* association, a process whereby several mental processes are almost instantaneously apprehended, not as a succession, but as a complex unit. Such combining of processes goes under a variety of names — perception, immediate recognition, conception, meaning. Each of these is the result of an integrating or fusing of related processes into an organic whole.

Possibly the essential difference between successive and simultaneous association is to be found in the greater habitualness of the latter type. If the time spent by the nerve-current in traversing synapses varies inversely with the resistance, and if frequency of use decreases resistance of synapses, it is but logical to expect that in the very familiar linking of experiences, the time interval between them would be reduced to a minimum. Other experiences, less frequently connected, would be separated by a greater

time interval. It seems probable, therefore, that perception is essentially a sophisticated condition resulting from many previous identical or similar associations which are aroused so close together as to give the impression of simultaneousness.

A still greater shortening of time is made possible by another group of circumstances. We have already seen that a sensation is the result of the action of the nervous impulse when it reaches the layer of cells making up the cerebral cortex. We have also found that the consequence of such stimulation is the creation of modifications in the nerve substance which when retained become the basis of memory. When we re-experience an object the conscious result must be a complex made up of the simultaneous awarenesses of the qualities of the stimulating object by way of sensation, and the recalled images of previous experiences resulting from the rearousal of the previously modified cells. The result is neither sensation nor image, but a mixture of the two, for when a nerve-current coming from a sense-organ arrives in an already modified brain region, the result must be a report of the external condition and also a rearousal of the memory. This integrated, complex process is an essential part of any percept. Added to it are the almost simultaneously aroused associates previously mentioned.

Perception is ordinarily defined as the awareness of *things*, sensation as the awareness of the *qualities* of *things*. A thing is at least the sum of its qualities, but it is, in addition, a group of relations — existing between the different qualities, between the thing and other things, and between the thing and the perceiving individual.

Consequently, perception is a two-sided affair. On the one hand, it is the simultaneous awareness of a group of sensory impressions, or qualities. For instance, a cup of coffee is a white — brown — bitter — sweet — warm — cold — pressure — odor — kinæsthetic complex.

On the other hand, perception is an awareness of relations which are drawn from our past experience. One of these groups is made up of the relations existing between the incoming qualities and our memories of similar qualities.

For instance, as we look at a tree, we perceive that it is *rough*. We do not, however, *see* the *roughness;* we see certain variations in color or brightness on its surface and these are translated by association into memories of sensations of interrupted pressure and intermittent muscular effort which *mean roughness*. An essential element in any perception is, therefore, a translation of one sense quality into other sense qualities.

The relations existing between the thing and other things take several forms. The more important are: first, space relations which inform us of where things are with reference to other objects and to ourselves; second, time relations, which inform us of the rate of succession of different events; third, cause and effect, which enable us to distinguish between accidental and necessary sequence of events; and fourth, the relations existing between the object and the perceiving individual, which are usually *use* associations.

Perception, then, is really a *group* of incoming *sensations* or qualities which have *meaning*. It is derived partly from the outside world and partly from mind. We perceive things not as they really are but as we have learned that they must be. That we do make such interpretations of in-

coming impressions in our endeavor to get meaning from the physical universe is demonstrated by the following examples.

If we look at a table top critically, we can see that there are two obtuse and two acute angles joined by straight lines. When we change our position slightly the angles which were previously obtuse become acute and the angles which were previously acute become obtuse, and from no position whatever can we see the angles of the table top as right angles. We know from practical experience that they are right angles and that it is possible to fit into a corner of a room which appears to be obtuse, the angle of the table which seems to be acute. In order to reconcile these apparent contradictions, we interpret and censor the incoming impressions and conclude that all of the four angles of the table are really right angles. This we must do if we are to live in a logical, orderly world, if we are to conceive the physical universe as a meaningful system.

The censors who do this work are exactly the same ones that we found in attention and association, namely, the ideas already in mind, our purposes, our attitudes, our education as affecting our past experience, together with our inherited capacities and ideals of duty. Each of them is supreme while he is on the job. Consequently, when one censor is in control, we interpret the physical phenomenon in one way, and when another is on duty, the same event has very different meaning.

For example, I sit looking out of my window and see a tree. My interpretation of it is an illustration to use in this book. Were I walking, it would be an object to avoid; were I reading, its trunk might offer support to my back and its

shade present a haven on a warm day. Were I cold, it would immediately suggest fuel; were I pursued by a savage animal, its branches would afford refuge.

Each of these different reactions is, of course, one which has been used in the past. All these interpretations are possibilities, but the one which actually occurs is the result of the present demands.

As human beings, we are, during the working-day, in a professional attitude. We are at the same time members of a family, members of a municipality, of a state government, and an even more inclusive political organization. We possibly are affiliated with a fraternal organization, a church, a number of clubs. Self-regard and self-interest are always present. These represent a few of the interests, attitudes, and purposes which determine the form of our perceptions.

To see how our self-assertive tendencies should be in harmony with the subordination necessary in any social or business group; to see how interpretations are made one way when one set of values is in the foreground of consciousness and a different way when a different group of values is in command, is easy in the light of the principles given above.

An incident in the morning papers may be unpleasant from the family attitude, but a distinct asset when our business self is to the fore. For example, the church which the contractor attends is struck by lightning. He regrets the damage which was done, not only because it is his church, not only because his friends will suffer by it, but because he himself is deprived of its refuge and solace. But at the same time he may know that he will be awarded the con-

tract, which may be a very pleasing experience to him as a business man.

In process of time we follow our natural tendencies to generalize. Those experiences and ideas which somehow belong together, which are similar in some respects, become coalesced. Our more sophisticated perceptions are the results of incoming impressions as modified or interpreted in terms of such generalized ideas, which are known usually as *concepts*. In so far as these concepts are really inclusive, interpretation in terms of them is largely *classification*.

It is largely for this reason that knowledge of fundamental principles is so great an asset to any one who has many decisions to make. If an emergency occurs, it may be classified in terms of sound business principles, in terms of sound moral principles, in terms of sound social principles, and in terms of sound patriotic principles. There are, at least, these four angles from which one can view the situation. Should these all be harmonious, the decision may well be immediate. Only where discord exists between some of them does the chance for involved reasoning appear.

The process of reading is itself an excellent illustration of perception. The words do not jump from the printed page over into consciousness; an elaborate series of interpretations intervene. Our early experiences are with concrete objects and situations. Soon the spoken word becomes associated with the object. When the awareness of the object itself or its copy image becomes connected with a symbolic sound image of the *name* and this in turn with the process of articulation, speech begins.

Learning to read consists of forming associations between

symbolic visual objects or ideas, the letters and words, and either the symbolic sound images or the visual copy images. By a substitution of equivalents, either may stand for any of the others, and the word eventually comes to mean the object. If we learn to read by spelling out the letters we get the sounds of the combination of letters and hence the meanings. Before long, however, we read by *word forms*, and a meaning, either by way of a copy or a symbolic image, becomes associated with the characteristic form of the word or phrase. When this degree of proficiency is reached, reading becomes rapid.

Experiments on the behavior of the eyes of one engaged in reading have added much to our knowledge of the operation. They show that the eye does not move slowly and continuously across the page; its progress is made rather by a series of jumps separated by pauses. It is during these pauses or "snap-shots" of the page that our reading is done. One or more word forms are apprehended and interpreted. Then the eye jumps to the right and the images of various other word forms are brought to consciousness for interpretation.

Since all "reading" is done during the fixation pauses, our rate of reading will depend upon both the number and the duration of the pauses. The time spent by the eyes in "jumping" from one fixation point to another is so slight that it may be disregarded, for approximately eighty-five per cent of all the time spent in reading is used up during the pauses. The first pause in the line is ordinarily the longest, about .25 second; the last pause is the second in duration, about .2 second; and the intermediate pauses are of comparatively brief duration, .10–.15 second, unless the

eye happens to stumble over an unfamiliar word, in which case the pause is considerably lengthened.

In view of these considerations, it would appear that the line having the greatest number of intermediate stops — that is the long line — would be most rapidly read. But experimental evidence decides otherwise. The newspaper column, having a line from two to two and one-half inches in length, and the page of the novel with a line three and one half to four inches long, are the ideal lengths for rapid and easy reading. Shorter lines and longer lines are read less rapidly and easily, for with them fixation pauses are not only more frequent and last longer, but refixations are made more often. When the right end of the long line is reached, the beginning of the next line below cannot be seen clearly enough out of the "corner of the eye" to insure accurate fixation, so mistakes, involving refixations, are common.

Size and character of type are also of importance in determining the number and duration of fixation pauses. Type which is too large or too small, too condensed or too expanded, too faint or too smudgy, makes reading slower and more difficult. Space between contiguous lines should also be great enough, but not too great.

Other illustrations of the fundamental laws are found in the perception of space, of time, of motion.

Space, psychologically considered, can be analyzed into three aspects: position, or where; extent, or how big; and distance, or how far. Furthermore, position is always perceived with respect to some perceiving individual.

To make this problem of perception of position concrete, take a soft pencil and with the eyes closed press it against

the back of the hand. Now remove the pencil and after a wait of fifteen seconds, and with the eyes still closed, find a spot in the back of the same hand that "feels" the same as the first. Press down upon it with the pencil. Open the eyes and see how far apart the two pencil marks are. Probably they will be separated about one-quarter of an inch. Repeated trials will disclose much the same tendency. But in general the error will be greater in the direction of the long axis of the arm. If the experiment is repeated on the finger-tips, the results will be similar though the gross error will be less. There exist, then, on the surface ellipses inside of which the qualitative "feel" of stimulations by the same object is identical, whereas the characteristic "feel" of one area is different from that of another. This peculiar "feel" has been known in the history of psychology as the *local sign*. This we may interpret to mean sign or mark of position.

What are the characteristics of the local sign? They are not to be found in the nervous terminations of the sensory nerves in the cortex, for the only conscious function of these nerves is the awareness *qualities*. Identical qualities might come from very different regions.

But since qualities are the only sources of cognitive experience and since the different brain regions involved in the awareness of qualities may be associated, we are compelled in the last analysis to turn to qualities and other simultaneous experiences that can become associated with the qualities. We learned in the discussion of sensations of the existence of four and only four cutaneous qualities — cold, warmth, pressure, and pain. Each of these sensations is the result in consciousness of the stimulation of a particular kind of nerve-ending in the skin. Since two different bodies

cannot occupy the same space at the same time, these nerve-endings must be found in different regions of the skin. Furthermore, no matter how a nervous ending of this sort, for example a cold spot, is stimulated, it will yield its own peculiar sort of conscious response — cold — if any result occurs. It is perfectly possible to arouse a cold sensation by a pencil-point or a needle as well as with ice.

This being the case, the stimulation of the specific point on the back of the hand may arouse a number of cutaneous qualities peculiar to that region and no other. The complex resulting from the stimulation of some other region may be noticeably different. Furthermore, the characteristics of the structures underlying the skin may be different in different places. As we press over a fatty region, or a bony one, or a muscular one or over a blood-vessel, certain peculiar "feels" will result. The skin itself, because of the arrangement of its sensory nerve-endings and also on account of the underlying tissues, provides for certain qualitative differences in sensation for the stimulation of different areas which may serve as signs of position.

Add to these the reflex tendency to move the hand to any region thus stimulated, and a group of kinæsthetic sensations and images emerge. Characteristic qualities of kinæsthetic data thus tend to become associated with the characteristic cutaneous qualities evoked by the stimulation of a certain spot.

Once again we find an equally strong tendency to *look at* the stimulated area. The visual awareness of the part of the body stimulated and the position of the stimulus makes the task of locating complete. By association, the visual memory may take the place of the visual sensations.

Thus we see that the *local sign* is a complex of associations,

consisting mainly of cutaneous, kinæsthetic, and visual data, which signify, or mean, a certain position. An extended description of visual local signs is unnecessary, for the type of exposition is similar in all respects to that just given.

The perception of extent is a more perplexing problem in one respect at least, for the extents to be compared must be, either actually or in imagination, at the same distance from the observer. When this condition is satisfied, there appear two conditions, either or both of which inform us of the relative extensity of the two objects to be compared. These are: first, the amount of the sense-organ stimulated; and second, the time and effort spent in moving the hand or eye or body from one end of the object to the other. It is probable that the kinæsthetic data are primary in this situation and that the meaning of the amount of sense-organ stimulated depends upon this.

Perception of distance is the result of the co-operation of many factors derived in part from the eye itself and in part from the relations and peculiarities of the perceived objects. From the nature of the eye three different kinds of data are derived. In the first place, the lens of the eye is flattened when the image of distant objects falls upon the retina and bulged out into a more circular form for near objects. This decrease in radius of curvature is accomplished by the contraction of the ciliary muscles. Contraction of the ciliary muscles in turn produces strain sensations and these strain sensations, by the substitution of equivalents, come to mean nearness.

Similarly, when we are looking at a distant object the eyes are diverged so that the lines of sight are practically

parallel. When the gaze is shifted to a near object by contracting the internal rectus muscle of each eye, convergence takes place. Convergence once more is accompanied by muscular strain, and muscular strain, as before, means nearness.

A third cue to distance, and the most exact coming from the peculiarities of the eyes themselves, is *double* images. If you will hold your two index fingers out in front of you about a foot and a half apart and then look at the near one, the image of the far one will appear double. As you move the doubled finger toward the nearer one, you will notice that the doubleness of the images becomes less and less; as you move it farther and farther away the doubling becomes greater. The amount of the doubling then serves as a sign of the distance separating the two objects. Now, while fixating the nearer finger, close the right eye, and you will observe the disappearance of one of the doubled images — the one on the same side as the closed eye.

Now reverse the procedure. Fixate the farther finger and notice the doubling of the image of the nearer one, which decreases in amount as the two fingers move closer and closer together. This time close the right eye and observe that now the image on the opposite side disappears. We are provided here with a mechanism which will tell us which of two objects is farther away from us and will give some indication of the distance between the two objects. But it tells us nothing of the absolute distance away of the object seen as single. In fact, our estimation of absolute distance is quite vague. Repeatedly have I asked students to estimate a distance of about 600 feet, and their average judgment is about 375 feet.

Data derived from the qualities and relations of objects themselves — the blue or purple distance, partial superposition and masking, clearness of details, etc., have been made too familiar by artists and their works to demand detailed discussion.

Perception of space by the ears is much less accurate than by the eyes. Position or direction from which the sound comes is perceived in part by means of the differing intensity of the sounds in the two ears assisted somewhat by head movement, and in part by the overtones and partials which are emphasized or dampened by the angle at which the sound-waves strike the external ear.

If sounds appear to be of the same intensity in the two ears, they are judged to be in the median plane, but whether in front of us, or behind us, above us, or below us, it is difficult to determine. If a sound is made in front of one and then repeated at the same distance behind one, the former sounds somewhat more intense than the latter, possibly because of the angle at which the ears are attached to the head. This difference in intensity can be of little practical importance, for in natural conditions, two sounds are seldom of the same intensity.

The distance away of the source of the sound is another factor which must be taken into account. If the intensity of the sound varies inversely as the square of the distance and if, furthermore, the limen for sound intensities is represented by the fraction one-third, then it is evident that slight intensity differences in the two ears can be appreciated only when the source of the sound is comparatively close to the observer. Since successive presentation of impressions yields more acute discriminations than simul-

taneous, a source of sound removed from the median plane of the head will, therefore, permit a greater accuracy of comparison than one in the mid line.

Time difference in the stimulation of the two ears may play another rôle in addition to facilitating comparisons of intensity. When the sounds occur simultaneously in the two ears, a source of sound in the median plane is the interpretation. When the sound occurs first in the right ear, it is interpreted to mean a source of sound somewhat to the right of the observer. However, sound travels through the air at a rate of about 1,100 feet a second. The distance from ear to ear, measured on the outside of the head, is not far from one foot. Consequently the maximum time difference would be not far from one-thousandth of a second, a period too slight to be of much practical importance.

That intensity differences and time differences are not the whole story is shown by the inability to detect the direction from which a pure tone comes. When the auditory field is investigated by means of a tuning-fork which gives an approximately pure tone, the average error in locating the source of the sound is practically 180 degrees only when directly in front or behind. In other words, it is pure guesswork. The sound seems to come from all directions at the same time. The observer usually says that he seems to be in the centre of a sphere of sound which seems to be coming from all points on the periphery.

This finding suggests that we must add to intensity and time differences another factor — sound complexity. Pure tones are the exception, not the rule. Most sounds are complex, made up of fundamental and overtones or partials. It is possible that the convolutions of the shell of the ex-

ternal ear, as the sound comes from one angle or the other, may dampen some of the partials and emphasize others.

Whatever be the data used in determining the direction from which a sound comes, the judgment is comparatively inaccurate. Supplementation by vision or touch is necessary before a certain judgment can be made.

Sounds do not possess the attribute of extensity or size, so there is no problem demanding discussion.

The distance away of the source of the sound may be gauged to some extent in terms of intensity. Changing distances may be appreciated similarly by varying intensity of sound.

Time, psychologically, consists of two sorts, passing and past. The measure of both is found in the events which fill them. Passing time is measured by quite different kinds of events from those used in past time. This is the inevitable outcome of certain peculiar illusions of the passage of time. Time crowded with events, as a football game, seems short in passing but long in retrospect; time empty of events seems long in passing but short as we look back upon it. We are compelled, then, to seek for two different units which can satisfactorily measure time and yet produce such opposite effects.

On this basis, then, we may say that passing time is measured, not in terms of the external happening and events, but in terms of adjustments of the organism itself. The most probable one is found in the muscular contractions accompanying anticipation or expectation. When external events occurring in fairly rapid sequence dominate attention, these adjustments change so rapidly that they never become sufficiently intense to divert attention. Conse-

quently passing time seems short. But in retrospect, many memory images are necessary to resurrect the situation and we infer that it must have taken a long time for all those things to happen.

On the other hand, when external events succeed each other slowly or not at all, passing time seems long. The reason is that now when external occurrences do not engage attention rapidly enough, it is turned inward and directed toward the strain sensations which spring from anticipation. These strain sensations grow rapidly in intensity, last about four seconds and then disappear, to be followed by others. Attention to them is a sign of nothing else to attend to; their endless identity kills interest, and the result is a condition of boredom. When this is recalled in retrospect, the time seems short, for there were no external events to fill it.

Perception of motion visually might conceivably result from a series of moving images crossing a stationary retina; or from the image of a stationary object dragging across a moving retina, or from a moving eye following a moving object. When the eye is stimulated by an object for a brief period there follows the removal of the object from the field of view an after-effect known as the positive after-image. When an image of an object moves slowly across the stationary retina, a series of such after-images linger behind. The most intense image is closest to the image of the object — the faintest most distant. From the existence of such a trail of after-images we can infer both the fact of movement and its direction.

The second condition mentioned above will not give the perception of motion for the following reasons. An eye that

is moving rapidly from one fixation point to another is practically blind to objects. This may easily be verified by performing a simple experiment.

A *X* *B*

Let the eye swing from *A* to *B* across *X* without pausing. *X* will not be seen during movement, only when the eye is at rest on either *A* or *B*. Consequently, an eye moving with this type of movement is incapable of perceiving not only the object, but also forming any series of after-images.

When both object and eye are moving, peculiar illusions of movement may result when no background is present. When a background is provided, relative displacement of object and background can be detected, and the movement is usually attributed to the smaller as the more probable object.

Summary: In perception we find a mental integration which enables us to know an external world and the relation of objects in time and space. Built in part upon knowledge and in part upon incoming sensory data, the perceptual world is a practical world, a half-way house between the physical or external and the purely mental or imaginary.

PROBLEMS

1. If perception is essentially an interpretation of entering impressions in terms of past experiences, show:
   (*a*) How it is possible to perceive the same thing in different ways.
   (*b*) How it is possible to perceive different things in the same way.
   (*c*) What experiences *mean* distance?

(*d*) What experiences *mean* size?
(*e*) What experiences *mean* position?
(*f*) What experiences *mean* time?
(*g*) What experiences *mean* movement of an object?
(*h*) How do we read?

CHAPTER XI

OBSERVATION

We saw in the last chapter that perception is a mixture or fusion of sensory impressions and of memory elements which supply the meaning. Either of these two aspects of perception may be emphasized at the expense of the other. When the memory elements predominate, the percept tends to be fiction founded on fact, for the sensory elements are enriched in the interpretation beyond all belief. The result is a series of observations of the utmost unreliability, as has been shown by many a cross-examination in or out of court. When the sensory elements predominate, accurate interpretation is equally impossible, for the external events crowd too rapidly to permit. Only as the two elements fuse in proper proportions do we get real and significant observations.

Many illusions of observation result because of the interpretation supplied by the central elements. The idea in mind, because it tends to expedite the entrance of external impressions, does at the same time supply an interpretation congruous to itself. The remarkable deceptive results obtained in real life as well as in fiction by placing a dummy in a bed is an illustration of this point. Many of the "authentic" visions of ghosts have this explanation. In fact, the only ghost I ever saw was the result of the setting, which in turn induced a mental attitude, which in its turn in-

duced a false interpretation of physical stimuli. A number of boys of the Penrod age were hurrying to a fire. The shortest way led through the cemetery. The hour was 9 P. M. and the darkness was that of a cloudy March night. This circumstance was sufficient to put us in a somewhat "creepy" attitude. As we entered the cemetery we could see the blazing house and realized it had been the home of a man killed some two weeks previously by a bull. With one accord we glanced in the direction of his grave and saw, just above it, a dancing, waving, beckoning white form, a ghost. We went to the fire, but not through the cemetery. Investigation the following morning by our elders showed that the firelight, reflected from a tombstone and interrupted by the swaying branches of a tree, produced the appearance of a dancing white figure.

The ability to observe things and their qualities depends upon the possession of all of one's sense-organs. Since each sense gives us a *fragment* of a *whole*, each of the sense-organs should contribute its quota. If one sense-organ is below capacity, observation suffers. For instance, a chemist finds his nose almost as useful as his eyes, for many substances which look alike can be distinguished by their odor. Similarly a locomotive engineer before he can see a hot box frequently smells it.

Observation also depends upon the possession of normal sense-organs. If the sense-organs are afflicted by any of the more ordinary disorders, certain possibilities of observation are lacking which may even involve one's fitness for a certain job. In the table on next page is given a list of some of the more frequent abnormalities with a few suggestions concerning the jobs from which one is thereby debarred.

ABNORMALITY	RESULTING DEFICIENCY	DEBARRED FROM JOB
Color-blindness. Red-green form.	Red and green indistinguishable	Railroad engineer or any other position where red and green signals are used.
Deafness.	Inability to hear sounds of normal intensity.	Salesman or switch-board operator.
Anosmia.	Inability to smell.	Tea-taster.
Diseases of taste papillæ.	Inability to taste.	Tea-taster, butter-sampler, etc.
Diseases of semicircular canals.	Lack of equilibrium.	Aviator, structural-steel worker, etc.

The ability to observe depends, in the third place, upon the store of memories which can be integrated with the incoming impression. The more we know about a thing the better fitted are we to observe it. If the fundamental condition of knowledge is discrimination, then much knowledge implies the possibility of much discrimination, and a discriminating observer is the one to whom slight differences are obvious and significant. It is not a great feat to observe that a motor-car has passed the house. The identification of it as a Buick shows slightly greater powers. Classing it as a Buick 4 is an improvement, and if, in addition we can name the model and year, that is about all that can be expected of the amateur observer. But each more specific observation was made possible by further and further discrimination of particular details.

The great skill of the North American Indian in tracking and hunting was believed for years to be the outcome of his keener senses. Yet tests have shown that the Indian

does not see or hear any better than the white. His superiority came from his greater power of discrimination, trained since earliest childhood, from the resulting knowledge of *what to look for, and from the ability to interpret what he saw.*

Ability to observe depends, in the fourth place, upon attention. We can attend to but one thing at a time and consequently can observe but one thing at a time. No one can, in the nature of the case, be a universal observer. For what we observe and how we observe it, depends upon our purpose, which in turn depends upon previous experiences. A geologist, a botanist, a fisherman, and a swimmer view the same stream with very different eyes, for they have been trained to interpret very differently the same objective situation because their previous training has provided very different experiences which may become the subjective condition of attention. Even though the same man may be geologist, fisherman, and swimmer, yet he cannot be all three at the same time.

On the reverse side, attention to one thing excludes simultaneous attention to something else. For this reason, those who live much in their memories are poor observers of external happenings. Similarly those of a reflective turn of mind do not shine observationally and for exactly the same reason. A certain receptiveness, a mental adjustment favorable to admitting outside impressions, is a necessary condition of observation.

Ability to observe depends, in the fifth place, upon the significance of what is seen. For meaning depends upon the substitution of equivalents, and if the equivalents are lacking, interpretation cannot take place. A thing which has no meaning for us is disregarded in favor of something that

has. We furthermore tend to select for observation the things of more immediate importance. The motorist is more law-abiding when the traffic-cop is seen.

A sixth factor in observation is the use we have for the observed situation. This in turn is largely responsible for the accuracy of the report of the observed fact. Many times you have looked at your watch, put it back in your pocket, yet, when asked, you have been unable to tell the time. The reason frequently is that you wished to see if it was yet time to do some task. If it was not, the exact time was of no use to you, so you forgot it immediately. Experiments show that only the essential features of any observed situation are accurately reported. Details of no immediate moment are either omitted or supplied from imagination.

Ability to observe such attributes as size, shape, position, motion, and speed are very unequally developed. In experiments on the psychology of legal testimony, several interesting facts concerning our ability to recall observed facts have come to light. The presence of persons is almost sure to be reported correctly. Their actions have a high interest value, but are related with a certain degree of inaccuracy, for many facts are left out and others erroneously supplied by imagination. The presence of essential things and their relative positions are reported quite accurately, but unessential factors, such as qualities and colors, are recalled incorrectly as often as they are accurately.

In brief, it has been estimated that only two-thirds of the incidents of any event are reported, and of those which are given only sixty-six per cent of the details are accurate.

The useful observation should point to the *future.* Any

observation is necessarily of the present. As such it has only immediate value and in a moment sinks into oblivion. But certain observations, instead of being merely history, indicate that *something* is *going to happen.* Such prophetic observations serve as a basis for regulating our conduct. Many of them appear as proverbs. Ground-hog's day is an example.

In a story which appeared a short time ago, two men were contrasted. One was a plodder who required definite figures and statistics before making a decision. He made up his mind slowly and then was always afraid that he was wrong. The other man was more spontaneous, having little use for statistics since he believed they show only what has happened and not what was going to occur. Given $5,000 apiece to invest, the plodder put his money in the savings-bank until he could investigate and decide upon a good safe and sound investment. The other, while driving to the golf club, noticed a factory which, heretofore idle, was putting in a new spur-track. He secured the name of the owners and bought stock, believing that the addition of a new track was a sign of coming activity. As usually happens in stories he was right in his surmise.

The difference between the two men is that one looked back constantly. He observed only those things which had happened. The other noticed occurrences which indicated future developments. If we can learn to distinguish between these two classes of facts, if we can learn to base our decisions upon those which point to the future rather than the past, we shall gain an untold measure of that quality known as foresight. It ought to be easy for a man who is on a job to suggest ways in which either the work or the working

conditions can be improved. If he finds any method which will save time for himself or for others, for those below him or those above him, he is making himself more valuable than a mere automatic machine. He becomes a thinker who can seize opportunities.

The greatest ally to progressive observation is natural laziness. Nature is lazy and we as nature's creatures share the trait. We get tired of doing the same thing time after time. It is said that Stephenson, who is so largely responsible for making the steam-engine a workable machine, had, when a boy, the job of tending an engine which pumped water from the mines. In those days before the engine had an eccentric, the passage of steam into the cylinder was controlled by a cock that had to be turned by hand. This monotonous task was Stephenson's means of livelihood. Not only was it uninteresting, but other boys were playing near by, and Stephenson, being a natural youngster, wanted to join them. He found, if he tied one end of a bent stick to the wheel and the other end to the cock, that the flow of steam was controlled automatically. He had developed the first eccentric. When his employer discovered Stephenson playing with the other boys he was very angry, but he immediately appreciated the real value of the crude invention and rewarded Stephenson.

Summary: Observation, like perception, consists of noticing and interpreting external occurrences. It involves, therefore, both sensory and memory processes. It is facilitated by keen sense-organs and a knowledge of what to look for. Trained observation consists in an ability to detect minute and more minute differences. The really useful observation demands not only the noticing of the existing

to be learned, as every skater knows to his sorrow. The biologist's argument is as follows: Acquired characteristics cannot be transmitted; a habit is an acquired characteristic; therefore, a habit cannot be transmitted.

The current explanation of instincts is rather along these lines. No two individuals are alike in appearance, structure, or behavior. Some peculiarities of structure or behavior are advantageous to the individual — that is, make living easier through easier access to food or easier escape from danger. Individuals possessing this advantage will, therefore, tend to live longer and have larger families, who, because of inheritance, will tend to possess the same advantageous characteristic. In an opposed way, those having disadvantageous characteristics will tend to live a shorter time and have smaller families. In time the balance will swing to those possessing advantageous structures and modes of behavior.

It is not necessary, in fact it would be absurd, to consider that all animals of a species possess a given instinct to an equal degree. It is much more reasonable to assume that about two-thirds of the individuals possess it to about an average degree and that about one-sixth are noticeably above and one-sixth below the average tendency. This corresponds well with what we know of individual differences in other respects and it furnishes an entering wedge in the investigation of the perplexing problems of character.

Much discussion has been aroused over the question of which is more important in determining a person's character, heredity or environment. As well ask which is more important, the foundation or the edifice reared upon it. When it comes to scientific investigation of the problem, almost

at some time in the future, be it immediate or remote. This follows from what has already been said, for if the origin of the desire is to be found in a want or lack, the satisfaction of the desire must occur at a time subsequent to the awareness of the lack.

This leads directly to the third point, namely, that the attainment of the object of desire leads to satiation. It follows logically from the previous point, for if lack is the cause of desire, the effect must disappear when the cause ceases acting. Therefore when the lack disappears, the desire goes away with it. This means that we do not desire the things we have. We may desire *to keep* them, a condition which certainly has a future reference, and we may desire *to use* them again, a condition once more which points to the future. As for desiring the same automobile, or watch, or razor that we already own and use, the thought is absurd. Certainly we are pleased that we have them, and should we lose them or be deprived of them would probably desire them again. Possession kills desire, though it may leave behind it a condition of pleasure.

Even if possession does kill desire for that one thing, it leads to a further desire, either for something different, or for some different attribute of the same thing. A desire for a bicycle may, when satisfied, give way to a desire for an automobile. This in turn may be supplanted by the desire for an aeroplane. So the vicious spiral mounts.

Likewise, familiarity with any article or situation will bring out its weak points or its inadequacies. The consciousness of these shortcomings leads in turn to a desire for a similar object with somewhat different qualities. If your automobile is a rough-rider, you naturally desire a more

upon the problem, and emphasizing and arranging in the proper order those which lead in the desired direction, and hence, eventually, to the solution.

The fifth step is the *proof*, which is a physical demonstration or test, if such is possible, of the correctness of the solution. This is made necessary not so much because we distrust our reasoning ability as because it is never possible to foretell whether we have taken into account all the necessary facts. When the physical proof is made, however, nature leaves no essential fact out of consideration. Physical proof, then, is more a criticism of our assumption than of our reasoning, though to be sure it does test the accuracy of both.

An interesting illustration is found in the invention of the Diessl engine, a machine which really made the submarine effective. The more antiquated form of submarine used gasoline for fuel. The fumes were easily exploded by chance sparks as many accidents showed. Diessl knew that compression of any substance makes its temperature rise. He thought that if he could produce sufficient pressure, he could use an inert, inexplosive substance which would take much less room than the ordinary forms of fuel. He obtained figures concerning the rate of increase of temperature of various substances with the increase of pressure. He found the burning-point of the crude oil which he expected to burn. He determined the resistance which should be offered by the cylinder walls as well as those of the chamber in which the explosion took place.

He obtained sufficient capital to enable him to make a model. When this was finished and things were ready for trial, interested persons were called in and put in positions

Anticipation consists not only in projecting ahead in point of time the present situation, but also in using the present situation as a starting-point for the recall of the subsequent experiences. In so far as frequency is a condition of recall and in so far as effect is the necessary and inevitable consequent of the cause, the effect of the present situation is favored in recall. The effect in turn becomes a cause leading to some further effect. The sight of dark clouds, because of past experience, suggests precipitation; rain in turn suggests umbrella; and thus one is prepared to meet the future emergency. This capacity to prepare for the future and to take advantage of the coming future condition when it has arrived, constitutes the most unusual form of intelligence.

In summary, the word intelligence is used to describe three types of ability. First is the perceptual form, an integrating of past and present to give meanings without specific temporal reference. This is shared by all normal individuals. Second is the bringing to bear on a present situation specific memory images of past experiences. In the third, either the present or the past is projected into the future and plans and adjustments are made with respect to the future contingency. It is probable that all normal persons use all three types of intelligence, but the first is used most frequently and the last or third with relative infrequency. In terms of supply and demand, then, the third type is the most valuable.

The three types of intelligence already outlined have been shown to depend on sensations and images which are cognitive conditions. Feeling and emotional responses are also possible. We are usually inclined toward the pleasant

the law of *perseveration*, already mentioned, the two or three movements just antecedent to the success tend to linger clearly in consciousness for some time — for four seconds at least, and then gradually disappear. During this interval the formation of the necessary associations goes on, and the next time the same movement is desired the last few steps or parts can be executed promptly. The pictured result, which is an idea in mind or purpose, is represented neurologically by an active brain region. And this active brain region, through its powers of *attraction*, tends to drain nervous activity toward itself from associated regions. The strongest associations, as we have seen, are with the brain regions involved in the steps just antecedent to the success. In fact, the movement is ended psychologically when it has reached the point from which all further movements are automatic or habitual. When this point is reached we get another perseveration tendency, etc., until the entire movement has become habitual.

When we have reached this stage of development, the next step is the elimination of useless movements, those having no essential part to play in the desired act. This is best accomplished by attending very clearly to the desired movement and forgetting the others, for by directing attention in one channel we act upon the synapses so that the nerve-current may flow more freely to the desired muscle group and less freely to others. When this process has been continued for some time we have gained control over a new group of muscles, and are able to isolate that movement from the more general responses which were present when we first started to learn the new habit.

It will be seen consequently that the *first essential in*

good follower, but never a leader. When the relative strength of the two factors is determined by external chance or mental fluidity, he is weak and vacillating.

As was pointed out in connection with desire, three factors must be considered in evaluating motives — the present condition, the means, and the end. When the present condition is highly satisfactory and likely to remain so, there is little impetus for change. Only when the present is annoying in its own right or by comparison with an anticipated future condition do motives come into their own. In this situation, antagonisms between means, between means and ends, and between ends themselves, may appear. When antagonisms appear either between means, or between ends, a selection ordinarily occurs before action begins. Only when means and ends are opposed do we find evidence of the compromise responses which appeared in connection with the running, skating, copying, and multiplying records.

In this connection, certain factors come to light which have much to do with the actual outcome. In the first place, we find evidence suggesting that when a present condition is opposed to a future ideal, the former is frequently, even usually, more potent. This is to be expected in light of the laws of attention. For a motive, to be effective, must be attended to. The ideal future possibility may initially have a high attention value, but, in so far as its realization involves prolonged or arduous effort, the cumulative intensity of the kinæsthetic and organic experiences may well divert attention to themselves. In this case, the forward-looking motive wanes and the value attaching to the more emphatic present waxes. Furthermore,

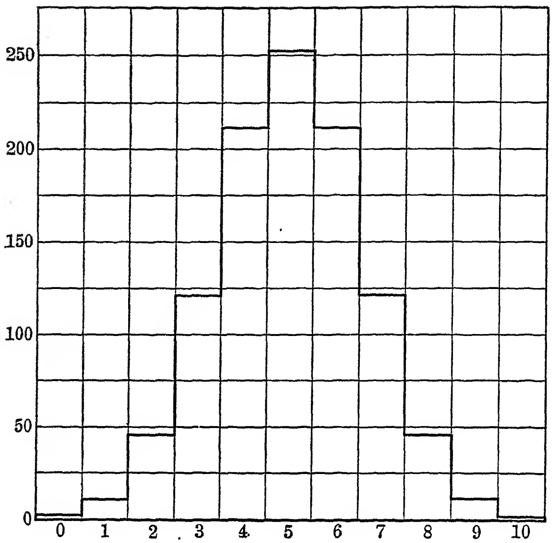


FIG. 30. Penny-tossing experiment.

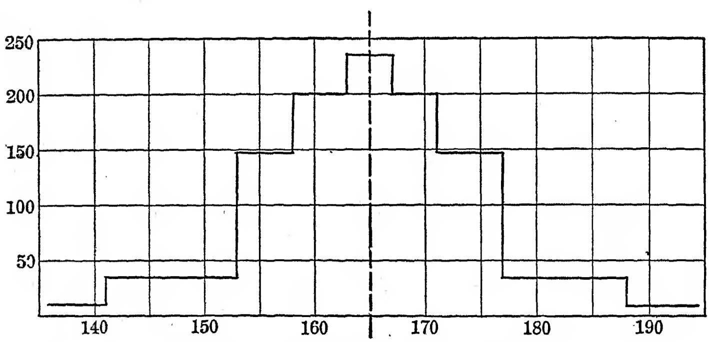


FIG. 31. Heights of French soldiers.